Design and BOQ of the Smart Sensory System for Posture Correction

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1 Introduction (Yassmine)

Poor posture, particularly when prolonged sitting is involved, can lead to various health problems such as back pain, neck strain, and muscle stiffness. The smart posture corrector has been developed in a way that incorporates a traditional corrector and uses smart technology in the form of sensors. Although they are more affordable, traditional posture correctors require a conscious effort to sit up straight and lack real-time feedback to inform users whether they are effectively correcting their posture. This design allows for additional detection of poor posture in the neck, duration and frequency of correct posture, and cases of leaning forward.

2 Schematic (Mostafa)

(a) Back View of the Brace (b) Front View of the Brace

Figure 1: Back and Front Views of the Brace

3 System Design (Nadim, Yassmine)

Our proposed sensor network is fundamentally a user-friendly wearable system, which incorporates a smart and distributed sensory framework for angle and pose estimation as well as posture misalignment detection. This being said, the problem statement would be evident, and it would pose itself as a question that would validate our design: *What are the sensors used to compliment that system? How are they configured hardware and software-wise? And for what physical body inclination would they be an effective estimation and detection tool?* This is a system identification problem, for that we should start by identifying the parameters of that system. To illustrate, we will be relying on three categories of sensors: The IMU incorporating a gyroscope and an accelerometer, four Flex sensors, and two pressure sensors.

We will start with the Inertial Measurement Unit (IMU) which possesses both an accelerometer and a gyroscope helping us in detecting a slouching posture on the central part of the back and estimating the angle of bend. The IMU needs an embedded system to communicate with, and for that we propose an Arduino Uno, also placed on the vest, for efficient and real-time data communication through the Arduino MPU 6050 gyroscope and accelerometer module on the Arduino board.[1]

Moreover, we move to the Flex sensors, particularly the Long Flex Sensor from Spectra Symbol, where we will need four of them, each placed in a vertical sequential fashion from the lower back up until the neck. Interfaced with the Arduino Uno, the Flex sensors would be able to estimate the body angle variations due to the possible physical inclination(s) on different parts of the back as well as measuring the angle of translation of the neck.

Moving on to the lower back, we would incorporate two Sphygmomanometer pressure sensors, each placed on one side of the rear lower back (one on the left and the other on the right), linked to two tubes where two reusable pressure bags are attached to them. With an incorrect posture in the lower back, possibly a lean towards the right or left, or an inclination in the lower back, the pressure sensors would be stressed, inducing air pressure across the tubes, and inflating the pressure bags. Therefore, our sensory network would be distributed across the wearable vest, and efficient real-time data transmission and communication for estimating and detecting anomalies in body posture would happen with a hardware network of wiring connections incorporating the sensors, the Arduino UNO, and the Lithium Polymer battery source.

As for the software, our focus will be developing algorithms in the Arduino IDE to process the input data from the sensors. This will be used to determine the user's posture and movement patterns. For the feedback mechanism, the Arduino IDE will be used to program the vibration motor to activate the system when poor posture is detected. Since there are cases where the user might be adjusting their position, a timer will be set for the comfort of the user. This timer will have a minimum delay of 10 seconds before triggering the vibration motor. Finally, we will use LabVIEW to simulate and visualize our results and for the calibration of the sensors. We will also implement a graphical user interface in the form of a website where users log in with their name, height, weight, and age, and it will display the output measurements of each sensor in real time.

4 Justification of Design Choices (Rayan)

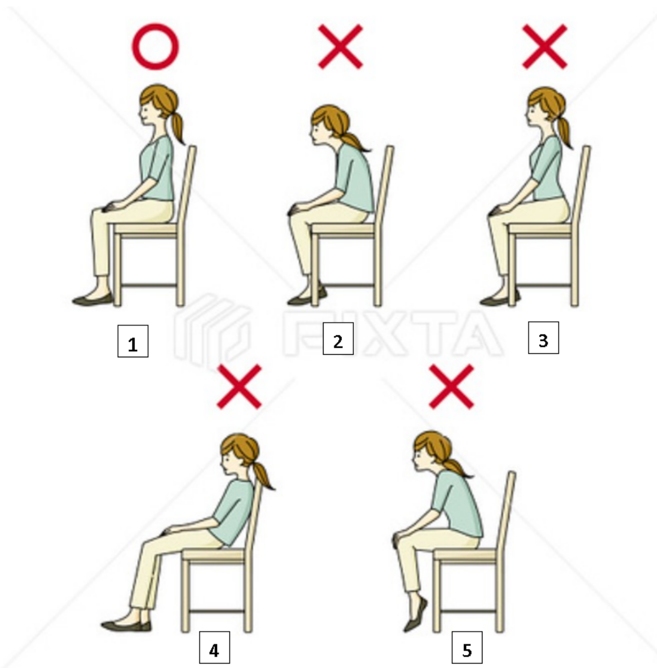


Figure 2: Different Sitting Positions

- This first drawing represents good posture, the spine is maintaining its normal posture.

- The second drawing represents slouching or hunching. The wearable device's IMU will obtain the angle of curvature of the back. If the angle calculated from the collected data is greater than 20 degrees, the Arduino microcontroller checks if there is a change in the flex sensor's resistance. The first flex sensor is placed strategically on the neck to accurately detect any form of slouching. Also, the second flex sensor is placed on the upper back, if the resistance of these flex sensors is greater than the prescribed resistance of 33000 ohms [2] the motor will vibrate and alert the person. Integrating the IMU with the flex sensor serves as a solution for faulty signals that result from the lack of differentiation between bending and slouching. This design allows two kinds of sensors to check for slouching, which improves the accuracy of the system and removes any false alarms.

- In the third drawing, there is the phenomenon of "Lordosis", which is the inward hunching of the spine. To this end, we will place a third flex sensor on the thoracic part of the spine and a fourth one on the lumbar part, and monitor their resistance.

- Regarding the last two positions, we will depend on the pressure sensors placed at the lower back, where the lower back won't be in touch with the chair and thus no or little variation in the pressure of the airbags will be detected. We might encounter some differences between the 2 airbags and this is because the back is not straight and there is some rotation and one side of the back is touching the chair while the other is not. Also, the flex sensor resistance will increase as the back is not straight and the spine is not in its normal curvature.

- To have a reliable power supply, we will use a rechargeable Lithium Polymer Battery of 3.7V and 600mAh. This battery is very small and lightweight which is convenient for our system. It requires charging by a Spark fun LiPo charger and it has an LED to indicate that the battery is fully charged. The wearer can charge this battery at night and wear the brace in the morning when sitting for work. Moreover, to obtain the vibration, we will use a vibration motor module that is programmed by the Arduino to vibrate when a bad posture is detected. Lastly, a person may perform sudden movements that are not slouching, thus we need a timer in the microcontroller that alerts the vibration motor to operate only after a minimum of 10 seconds of slouching detection and this will done in the software part.

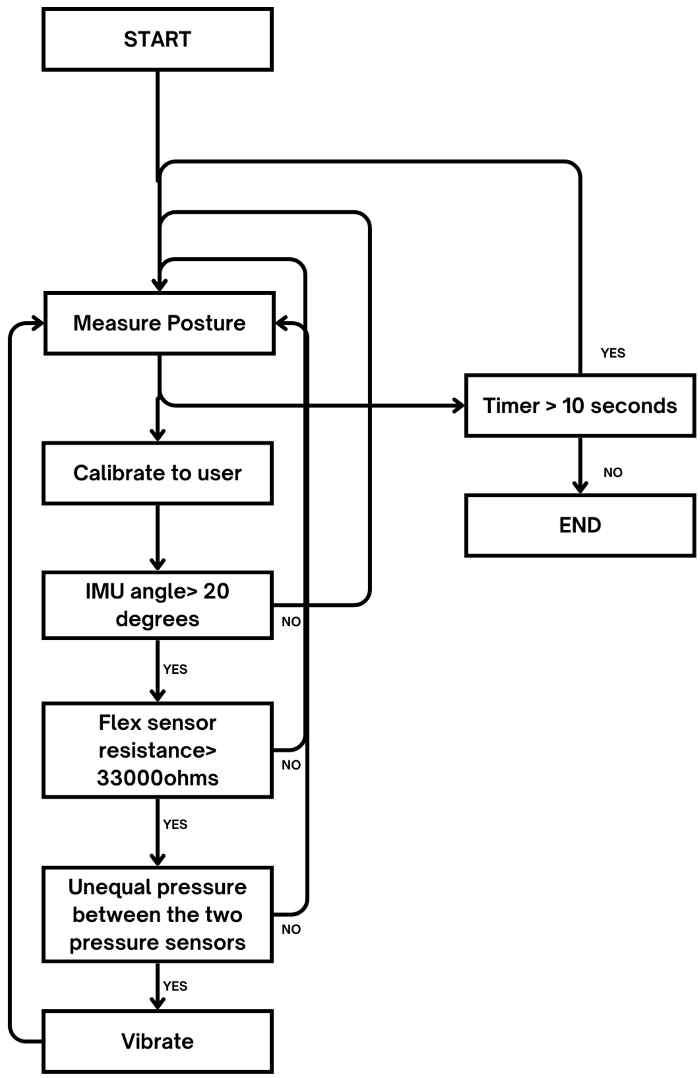


Figure 3: Flowchart of the Microcontroller (Rayan)

5 Bill of Quantities (BOQ) (Mostafa)

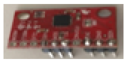
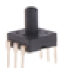
Picture	Componet	Code	Source	Quantity	Unit Cost	Total
	IMU	Arduino MPU 6050	AUB	1	NA	NA
	Microcontroller	Arduino UNO	AUB	1	NA	NA
	Sphygmomanometer Pressure Sensor	MPS20N0040D-D	Narinco Micro S.A.R.L.	2	0.4$	0.8$
	Flex Sensor	Long Flex Sensor from Spectra Symbol	AUB	4	NA	NA
	Vibration Motor Module	Arduino Youchuang 1027	EKT	1	0.75$	0.75$
	Posture Support Brace	Real DoctorsITN-728-121	Ishtari	1	8$	8$
	Wires	Black & White	AUB	NA	NA	NA
	Reusable Pressure bag	Pressure Bags	Pharmacy	2	6$	12$
	Lithium Polymer Battery	EKT_393703	EKT	1	3.75$	3.75$
	Bread Borad	NA	AUB	1	NA	NA

Figure 4: BOQ

6 References

[1] ÖZGÜL, G., PATLAR AKBULUT, F. (2022). Wearable sensor device for posture monitoring and analysis during daily activities: A preliminary study. International Advanced Researches and Engineering Journal, 6(1), 43-48. https://doi.org/10.35860/iarej.1018977
[2] Alsuwaidi, A., Alzarouni, A., Bazazeh, D., Almoosa, N., Khalaf, K., Shubair, R. M. (2018). Wearable Posture Monitoring System with Vibration Feedback. arXiv (Cornell University). https://arxiv.org/pdf/1810.00189.pdf