Back Posture Detector Extension

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Vignesh Sridhar
Shubham Agarwal
Venkata Krishna Vishal Guntupalli

Contents

Introduction

According to the American Chiropractic Association, 31 million americans experience low-back pain at any given time. Lower back pain is the single leading cause of disability worldwide,and back pain is the second most common reason for visits to the doctor's visits, outnumbered only by upper-respiratory infections. Furthermore, Americans spend at least $50 billion each year on back pain. A study done by the Agency for Healthcare Research and Quality showed that most cases of back pain are mechanical or non-organic, meaning they are not caused by some major illness. National Center for Biotechnology Information states that acute episodes of back pain are associated with muscle strain.

A major player in back pain is poor posture, something many who work a desk job can relate to. The typical method of fixing/correcting posture is just "remembering to sit up straight". However, until muscle memory has been formed, this is difficult and as a result, many never "learn" proper posture, potentially resulting in injury.

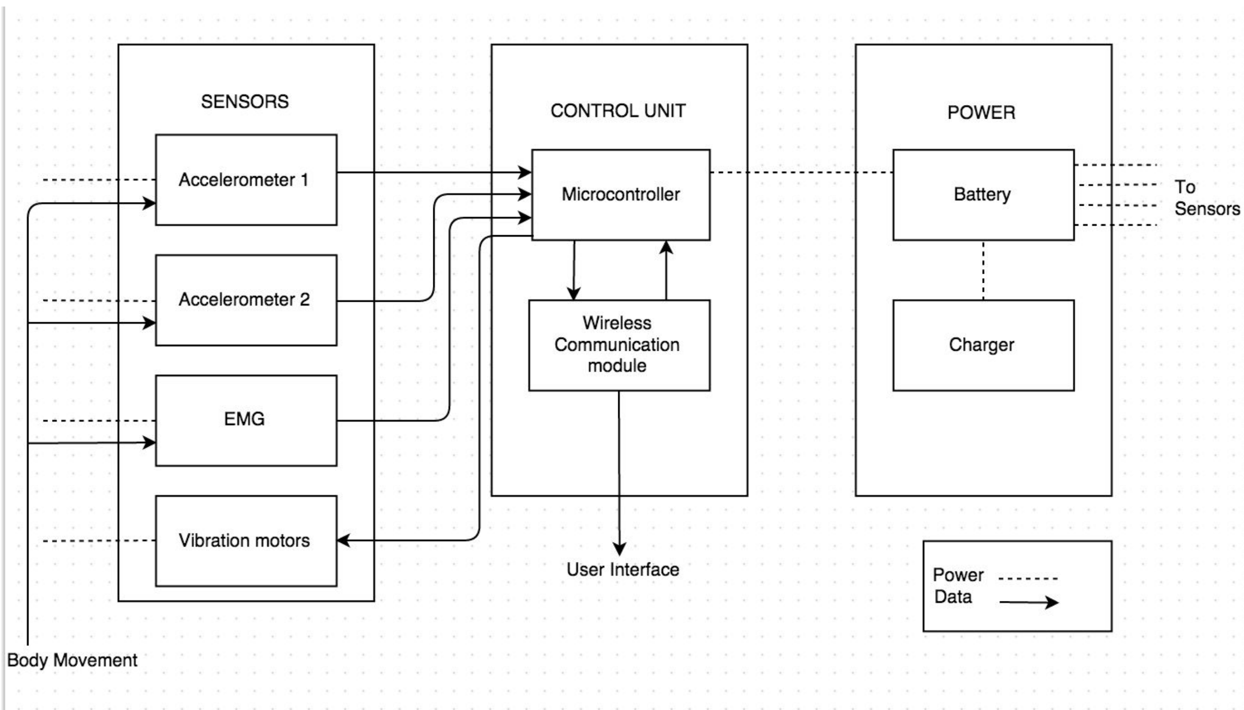
The 'Slouch Detector/Posture detector' was a ECE 398/445 project, using two accelerometers attached to the back; one near the base of the spinal curve and one near the top to measure the posture. We will be adding features to the project, giving more functionality to the user and solve the problems faced in previous semesters such as perfecting the method of mounting the device, designing a product which can be comfortably worn and improving the accuracy of bad posture detection. We will also try to add sensors to cover the horizontal axis, and measure muscle flexity to see how these factors affect posture in totality.

We will be giving users a more flexible choice in calibrating the way they want it. This flexibility for users means that the product would be perfectly able to understand the user's physical posture and give very accurate and personalised corrective feedback. Also we want to check the tension in the muscles which are normally affected by posture problems and want to alert the user about this. This gives us a stronger hold over the position of the user and makes sure that the user's posture is maintained.

We selected this project as we thought that there is a very dire need for such a product in the market. There is only one other such thing in the market, 'Lumo Lift' and that too does not seem to give very precise results and does not have too much that it monitors. It also has a different approach to the measurement of posture including the use of a gyroscope. We are sure that with the growth in a sedentary lifestyle, more and more people will be affected by posture problems.

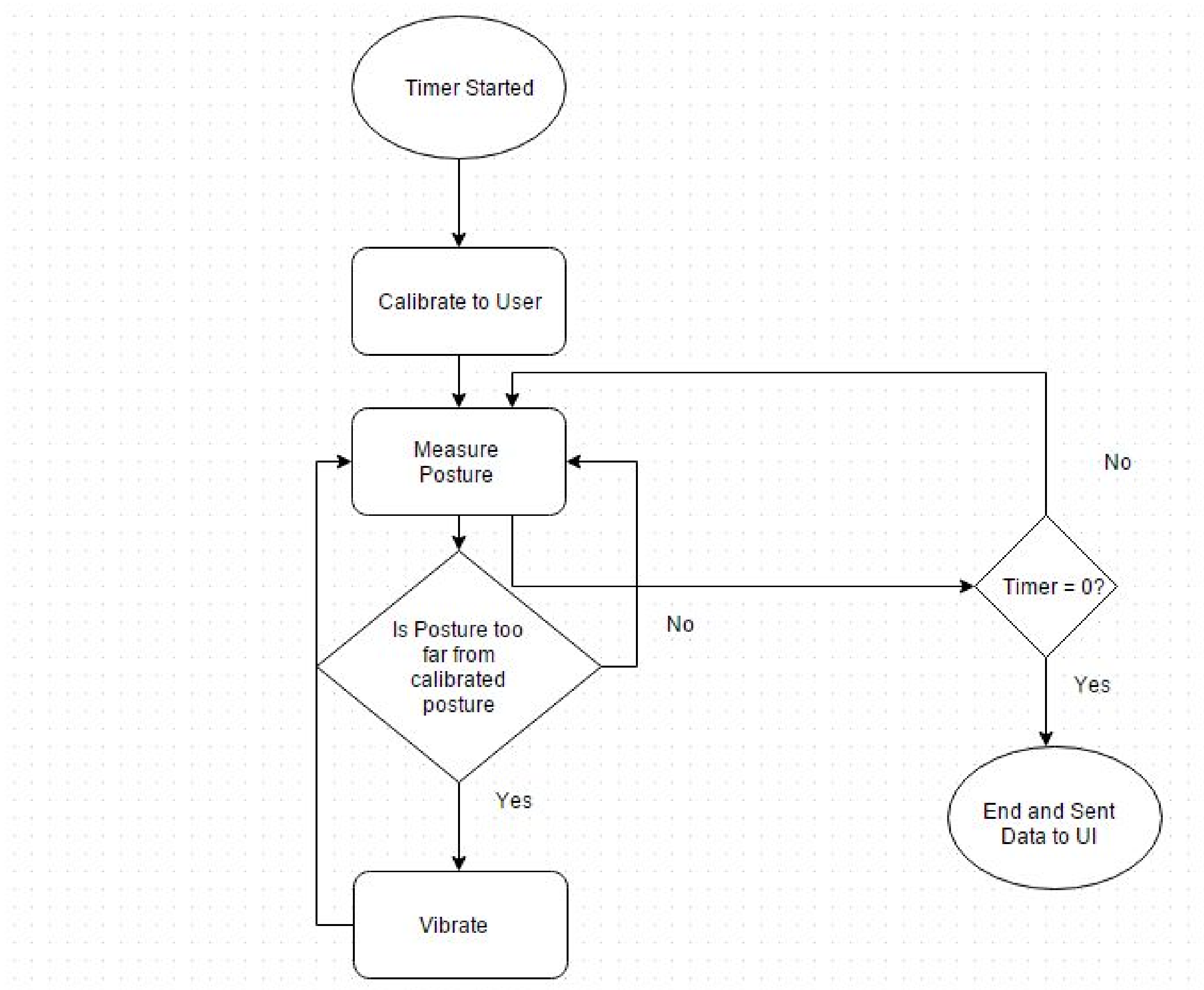
Design

Block Diagram:



Dotted lines	Power going out from battery. Charger sends power to battery
Arrows	Shows direction of flow of logic/signal. Body movements signals are picked up by the sensors. Wireless module will send data to computer/phone.

Software Diagram



Block Descriptions

We have described the input, purpose, and output of each block below.

Sensors

Muscle Flex Sensor (EMG) :

- Movement/tension in muscles will send an input signal which will be picked up by the EMG

- Checks whether the muscle is tightened or loosened.
- Sends a high or low signal corresponding to the muscle tightened or loosened.

Accelerometer:

- Movement in the body, and changes in posture will change angles measured by the accelerometer. Thus, body movement will act as input to accelerometers.
- Measures the acceleration at the base of the curve of the spine and the top of the curve of the spine. Thus, calculate the angle by which the person is bending and check if threshold is crossed.
- These values are sent directly to the microcontroller which can be used to calculate the angle differential.

Vibration Motor:

- Takes a high or low from the microcontroller
- Vibrates if it is high and indicates to the user that they are not in a position that has acceptable posture.
- The output is the vibration and we will have a regulator to control the duration and signature of vibration so that this is a comfortable signal for the person using this device.

Control Unit

Microcontroller:

- Receives data from the sensors and also the wireless communication module.
- Computes the angle of the back through the accelerometer data and also sees if the muscles are flexed. If any of these values cross the specified threshold values; then it knows if has to signal one or more motors.
- Depending on the settings the microcontroller sends a signal to the vibration motor(s) if the posture is not acceptable.

Wireless Communication Module:

- Takes the angles and muscle flex data from the microcontroller and relays them to a computer.
- If there is a change in the setting, relays back the new parameters.
- We will try to have a smart algorithm here that uses minimum energy to transfer data. The output can be seen on a computer in form of a graph maybe.

Power:

- The only input will be a charger such the battery pack can be recharged. Given time, we would like to implement a charger module as well.
- The output would be controller current and voltage for which a regulator can be used.
- We can simply power the device with small and portable batteries (2 AA).

Technical Overview:

The project is slightly more work than we thought initially. This is because we have to design the sensor board, and implement the posture detector as a use case for it. We also have to improve the posture detector by adding more use to it. We will further aim to give users a wireless interface with which they can have complete control over the data from these posture and muscle flex detectors.

One of the most difficult things in the project that we speculate is getting the muscle sensors and accelerometers to calibrate and give accurate results. To make both of these to work simultaneously, we will have to have a good design in place and also a good algorithm for the detection.

We will also try to implement options for the user to choose how much he wants from the detectors. Does he want muscle flex sensors or not. Furthermore, positioning the accelerometers for different heights means we will have to try this on different people and see that it can universally adapt to all kinds of body shape and structure. This will require lots of testing and trying various different positions.

One more thing we have to keep in mind while designing everything is that this can be made a wearable device. Thus, we have to consider safety. The device should not heat up, should be able to stop in case of emergency, and should also be tested thoroughly for all cases such that it does build heat inside it and does not react to anything that can be on skin. The material used also has to non reactive.

Considering the current market, a similar product called ‘Lumo Lift’ exists. However, according to online reviews, it is a device which is attached to the lower back of the body only. Our product will have a sensor on the lower back as well, but also another sensor on the upper back. Thus, we hope to capture additional posture data and see how the upper back affects the overall posture.
Moreover, Lumo Lift does not measure muscle flexity and we would like to add that feature. Thus, we should be able to measure muscle strain and realise how stressed muscles affect posture.

Block Level Requirements and Verification

Requirements:

We would need a couple of accelerometers, a couple of muscle flex sensors, some flat wires, power source like battery, and the designed pcb. We might want to add a wifi shield; so that may be additionally required but we will have to provision for something like that in the design itself.

Parts needed	**Quantity**
Accelerometer	2 => This quantity might change. We might increase this to improve accuracy. We might decrease this to make it a marketable product.
Muscle Flex Sensors	2 => This quantity might change. We might remove this if it seems to be a hassle to wear. We might also consider stretch sensors instead, if we make it a wearable device.
Vibration Motors	2 to 4. Depending on if we can capture the horizontal axis as well.
battery.	2AA - 3 to 6 V. We might change this depending on power consumption. Also we might replace it with a much smaller lithium ion battery if it seems suitable later.
pcb, wires, tape, soldering	-

I think these requirements can be met pretty easily. We will go through the testing phase first where we will test all the components separately and see if they can be compatible. We might have to write some drivers to connect the components, but that should be straightforward according to our research.

Verification:

For the testing phase, we will hook up the accelerometers and will have to see how it responds to changes in position. We will have to check calibration for them but we have a pretty fair idea of how to do that.

The muscle flex sensors can be simple tested by hooking them up to an arduino and collecting the data we receive.

The problem we might face in the software part of the project is differentiating between signals received from the muscle flex and accelerometers and how we will process them on our pcb.

Moreover, our initial design might be somewhat aimed to get the thing to work, and maybe after that we will try to make it such that it can be made as a product that can be worn and removed easily. It will be very difficult for someone to wear all this separately everyday and remove it.

Plus, one more thing we have to keep in mind is the material we use to cover these parts. We have to take care of allergies as this will be touching the skin for long periods of time.

Module	Requirement	Verification
Accelerometer	Need to return valid readings with accuracy to the nearest degree along an axis for a full 180 degree motion.	We will connect it to an Arduino and rotate along an axis printing data real time.
Vibration motor	Will buzz for a set period of time and does not keep vibrating. Plus, we should be able to set a high limit on the amount of vibration.	The vibration should be a comfortable vibration. We can limit the amount of current flowing out to the motors according to the specifications of the motor.
Battery/Voltage Regulation	The voltage supplied has to be greater than 3.0V regardless of spikes from the vibration motor. No liquid such as water or liquid goes through the case containing the battery and affects the functionality.	Connect the PCB, accelerometers, vibration motor, EMG and check for voltage drop with multimeter. Spray water lightly along the case and see whether the functionality is affected.

Muscle flex sensor	Should be able to detect muscle flexity so as to measure the horizontal axis of motion.	Place it on to a standard mannequin and emulate the motion, through an arduino, see the real time data and see if detection works.
Wireless Communication Module	Should be able to work very efficiently and wake up at certain intervals to send data to phone/computer.	Should consume very little power so that the equipment can work longer. Will need a good program as wireless devices waste power very quickly when trying to connect to other devices. Also, we would like to store and send angle and other data as much as possible so the person can see a chart of how his/her posture changes over time.

Tolerance Analysis:

The most important part, and probably hard to implement part will be the communication module. We have to see how to make it compatible with the pcb and how to make it send data efficiently.

Such modules will constantly have a problem of consuming enormous amounts of power and we have to find a good method to prevent this.

Getting accurate data is the ultimate use of the gadget. If we can transfer relevant and large amounts of correct data, the person can see a very accurate chart of how and when his body posture changes over time. This can be used for medical study, correcting habits, and to see if some correlation exists between posture and the work being done at that time of the day.

As a specific test, we will constantly change the position of the accelerometers and EMG sensors (if any), so that the captured data can be sent across and seen on a computer live. We keep doing this until a fully powered battery runs out with the wireless module connecting and sending data constantly. We will also test this when the wireless module is turned off.

This will give us the exact amount of energy the wireless module consumes from the battery and the time is lasts. If the person has to change the battery every 3 or 4 days, then they will spend a lot of money on just batteries, and this is not feasible.

Thus, batteries should be either rechargeable or be replaced entirely by lithium ion batteries with better efficiency, so that they can be recharged and can also run longer.

Further, to develop on the power supply, we will definitely have to add some sort of a power regulator like LM7805 to create a specific range on input power/volt supply.

Cost and Schedule

Cost Analysis:

Labor:

Name	Hourly Rate	Total Hours (12 weeks * 15 hours/week)	Cost per person
Vignesh	$35	180	6,300
Vishal	$35	180	6,300
Shubham	$35	180	6,300
		Overhead cost	2.5 times the overall cost
		Total Cost	18,900 * 2.5 = 47,250

Parts List:

Electronic components	Cost
Wireless communication module	$35
muscle flex sensor	$20
Accelerometers	$40
Motors (including charger, circuit to recharge battery without removing it from original case)	$60
Wires, taping and other small things	$30
PCB	$5

Total cost	$190

Schedule:

We will all be involved in designing the pcb and the communication module as that is the crux of the course. After that is done, we will try to divide work amongst us as evenly as possible.
One can handle the muscle flex sensors entirely and the other one can handle the accelerometers. The third person will have to take care of programming the wireless module and reading the data from it on a computer.

However, we will have to every now and then work together or at least in pairs so that everyone is on the same page and so that one single person does not become overwhelmed by the assigned workload.

A more planned schedule is described below:

Weeks	Progress	People working on it
7th-13th Feb	get proposal made and discuss with TA. Submit proposal and start with initial design and thoughts on how to start making it. Select a slot for Mock design review	Vignesh Vishal Shubham
14th-20 Feb	Order parts and get everything together Mock design review Work on the eagle assignment	Vishal Vignesh Shubham
21st-27th Feb	Finish verifying everything so we are sure we have all the parts and don't have to wait later. Design review sign up Complete Lab safety training Soldering assignment	Shubham Vishal all have to do Vignesh

28th Feb-5th March	finish pcb design. Design Review	Shubham Vignesh
6th -12th March	Send pcb design to fabrication lab to be made Work on designing other parts	Vishal
13th-19th March	Start assembling things after getting back pcb Start testing all the assembled things	Vishal
20th-26th March	First revision of pcb Test everything and see what final parts will be needed Spring break. Finish whatever has been still left from previous weeks to stay on schedule	Shubham Vignesh Vishal
27th March-2nd April	Mock Demo Individual progress report Requirements and Verification final attempt due	Vishal all have to do Vignesh and Shubham
3rd-9th April	Mock Demo Finalize final design	Vignesh Shubham and Vishal
10th-16th April	Finish final design Mock Demo	Shubham and Vishal Vignesh
17th-23rd April	Demo sign up Mock presentation sign up Start working on final paper	Shubham Shubham Vignesh and Vishal
24th-30th April	Demonstration Presentation sign up	Vignesh Shubham
1st-6th May	Turn in final papers Lab checkout	Vignesh and Shubham Vishal
7th-15th May	Final exams	