Budget Clip-On Posture Checker

Team 33

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I. Introduction

Objective and Background

Problem

Today, people work long hours at desks, either using their computers or mobile devices. This leads to poor posture whether it be through rounding shoulders, slouching, or tilting their head forward. These poor habits can lead to chronic neck, back, and shoulder pain, fatigue, and possibly some spinal and musculoskeletal issues. Most of the time people subconsciously fall into a position of poor posture and don't notice its negative effects until they experience discomfort. Current solutions include either having a tight brace which is restrictive and expensive, an application that uses cameras which require users to sit in front of which is tedious and impractical, and reminders that occur without measuring actual poor posture which people tend to ignore. There needs to be a discreet solution that can accurately monitor posture in real time, provide immediate feedback, and is portable. There is such a product on the market but it's expensive and we believe we can make a more affordable option.

Solution

The Clip-On Posture Checker will be a small wearable device that is clipped onto the user's upper shirt or upper body, with the additional use of shoulder straps as well. This device will continuously monitor the body's orientation and its deviation from proper posture. Everyone's proper posture is different which is why the device has a calibration button the user can press when sitting/standing in their proper posture, after a set time the device will be calibrated. Within a set parameter, a deviation outside of this calibrated range will trigger immediate feedback. When the user slouches or leans forward a lot, the device will immediately provide haptic feedback which will prompt the user to correct their posture.

Objective and Background

Goals:

- Get people to maintain good posture for extended periods of time
- Avoid back pain, muscle stiffness and respiratory issues

Functions:

- Calibrate to the user's definition of "good posture"
- Use sensors to monitor if the user is maintaining good posture
- Give real-time feedback via vibration if the user's posture deviates too much from their ideal

Benefits:

- Portable and affordable; accessible for those who work office jobs or always on the go
- Less pain caused by poor posture when sitting for extended periods of time

Features:

- Lightweight clip-on to avoid causing irritation to user
- Real-time feedback to notify user of extreme posture deviation
- Portable for users who want to take the device on-the-go
- User-friendly; minimal buttons to calibrate the device and turn the device on and off

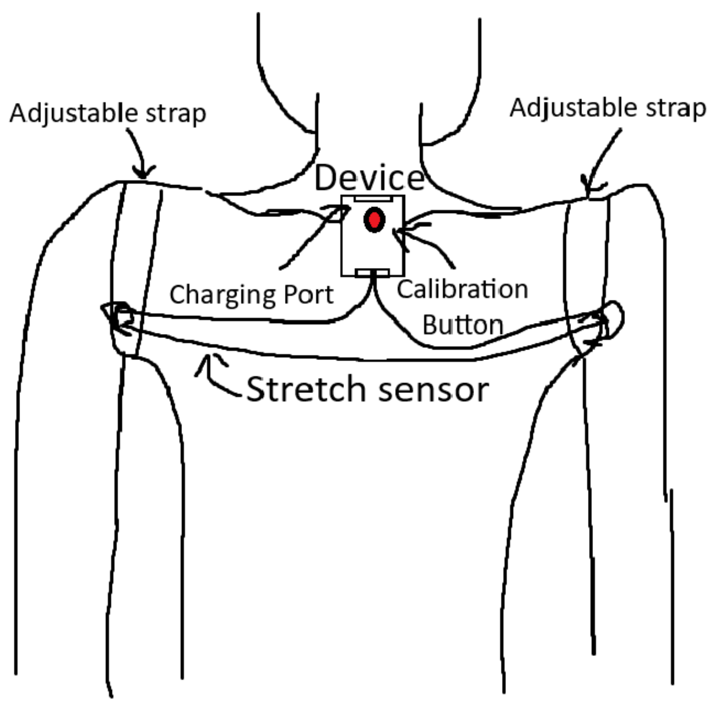
High-Level Requirements

- The device shall detect the user’s torso tilt angle relative to the calibrated upright posture with an accuracy of at least ±5°.

- The device shall provide real-time feedback (vibration or LED) within 3 seconds of when posture deviation exceeds a threshold angle (e.g., 15° forward lean).

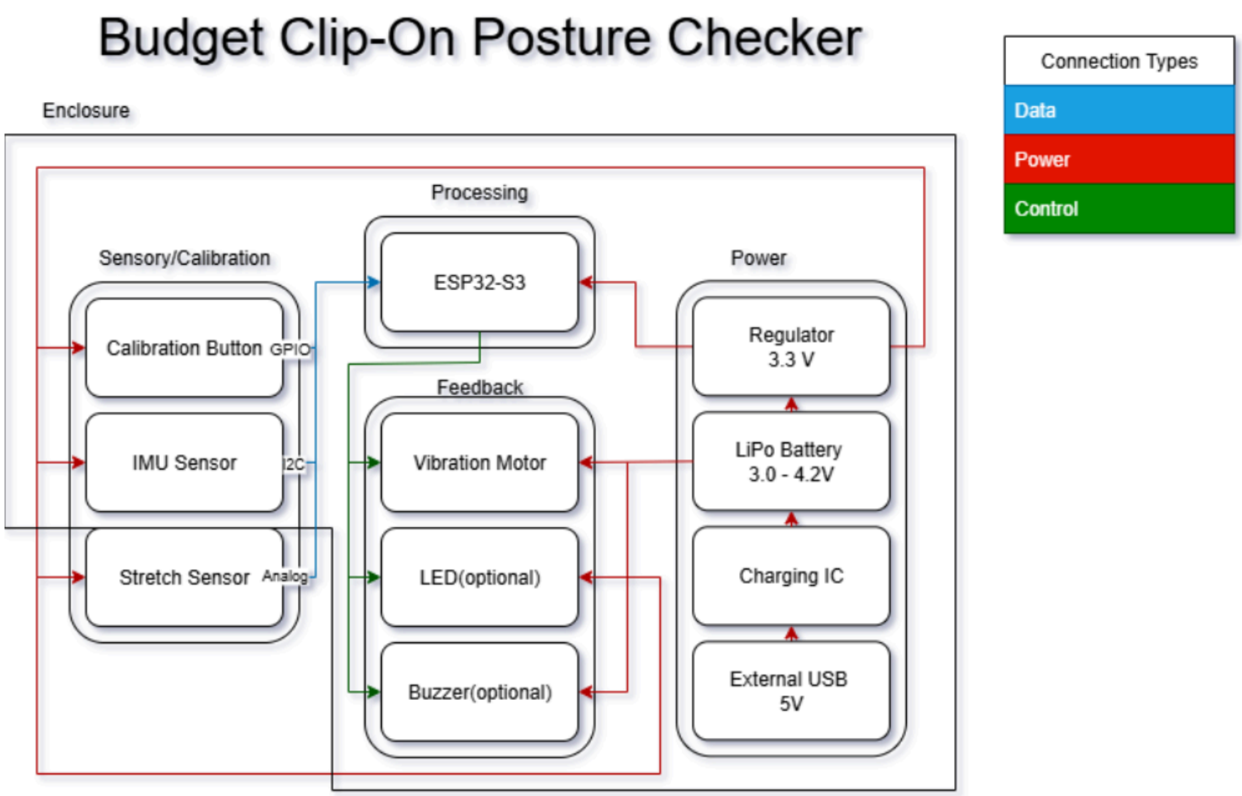
- The stretch sensor attached to the clip-on device will act as a secondary point of measurement to ensure accurate measurement of posture deviation from calibration. It will detect elongation of the shoulders corresponding to poor posture with ± 3mm change in length, to help distinguish between breathing and posture deviations.

Visual Aid



II. Design

Block Diagram



Block Descriptions–Functonality and Requirements of each component

1. Processing

   1.1. The processing subsystem goal is to process the received data from the sensor, combine the readings from different sensors, calculate and detect the deviation from the calibrated position, ensure power management, and ensure that feedback is provided at the right time. We will use the esp 32 chip in our processing subsystem as this chip is most suitable for our usage because it has built in wireless connection which can ease debugging and logging of data. Additionally, this subsystem is the core to our project and will be connected to the sensory, power, and feedback subsystem to receive and send data.

      1.1.1. Requirement 1: The MCU should read the IMU and stretch sensor at ≥ 50 samples/second and should calculate the posture readings at ≥ 20 times/second

      1.1.2. Requirement 2: The device should connect with the feedback system in $\leq$ 2.0 seconds after a deviation from calibrated position is detected

      1.1.3. Requirement 3: The MCU should trigger an alert when it detects a torso tilt of $\geq 15°$ from the calibrated position or when the stretch change is > than the threshold. And this deviation should be maintained for ≥ 1.0 second

2. Sensory

2.1. The sensory subsystem goal is to measure the user's body orientation and also the back curvature in relation to the user's calibrated position. This subsystem will contain an IMU (ICM-20948), a resistive stretch sensor and a calibration button. This Subsystem will be connected to the Processing subsystem as the data collected in the system will need to be processed by the processing system.

2.2. IMU (ICM-20948)

2.2.1. The IMU that we chose to utilize in this project is the ICM-20948 as this contains both an accelerometer and a gyroscope which will be crucial in detecting the user body orientation and determining whether it deviates from the calibrated position

2.2.2. Requirement 1: The IMU shall communicate with the MCU over I^2C at 3.3 V with a bus speed of ≥ 400 kHz

2.2.3. Requirement 2: The IMU shall provide accelerometer and gyroscope readings at ≥ 50 Hz which results in 50 readings taken per second

2.3. Stretch Sensor

2.3.1. The stretch sensor we will use is 12/14” Flexible Stretch Sensor, this will help detect the curvature of the back and will help detect any slouching in the user's body orientation and is crucial in detecting the deviation from the calibrated position. This will be done by using a simple voltage divider circuit to measure the change in voltage as the sensor stretches. The user will be required to wear adjustable shoulder straps with anchors for the stretch sensor to attach to.

2.3.2. Requirement 1: The system shall detect a change in stretch of ≥ 3 mm across the shoulders averaged over 10 seconds

2.3.3. Requirement 2: The Stretch sensor shall communicate with the MCU at 3.3 V, 12-bit ADC at ≥ 50 samples/second.

2.3.4. Requirement 3: The signal will be set at 1.65 to be able to detect both a stretch and slack at 0 V and 3.3 V.

2.4. Calibration button

2.4.1. The calibration button is used to be able to capture the users desired position and be used in calculating deviation.

2.4.2. Requirement 1: The calibration button should only detect a single press per time which will be done through a debouncer with 20ms

2.4.3. Requirement 2: The calibration button shall be held for ≥ 2 s to initiate calibration, and storing the current body orientation as the baseline and a slight buzz to indicate success

3. Power

3.1. The power subsystem's goal is to be able to deliver power to the required components, ensure user safety, be able to be recharged, and be able to meet the 8 hour battery life requirement. For the power subsystem we will use a 3.7 V Li-Po or Li-ion battery (tentative) as this will be able to provide enough power to run for 8 hours and compact enough to fit in our enclosure. The power subsystem will be connected to the sensory, feedback, and processing subsystem as all subsystems require power to operate

3.1.1. Requirement 1: The system should be able to use the single-cell 3.7 V Li-ion/Li-Po battery ≥ 200 mAh to operate for >= 8 hours

3.1.2. Requirement 2: The power system should also be able to provide 3.3 V with slight deviations at 150 mA

3.1.3. Requirement 3: The battery should be able to be charged from 5 V USB (tentative)

4. Feedback

4.1. The goal of the Feedback system is to let the users know if they are currently in poor posture in a timely and comfortable manner. The subsystem consists of a vibration motor, a LED light, and a buzzer. The subsystem is connected to the output of the processing system such that the subsystem will activate if the processing system dictates that the users are in poor posture. There should also be a means to turn off any feedback subsystem in case of a quiet environment.

4.2. Vibration Motor

4.2.1. The vibration motor we will use is VC1030B823L(tentatively). The motor should produce a haptic response lasting 200–500 ms in less than 500ms whenever the processing system dictates that the users are in poor posture. The haptic response must be gentle and perceivable for best user experience.

4.2.2. The vibration motor should be able to use the power line from the battery directly (with modifications if needed).

4.3. LED light

4.3.1. The LED light we will use is Red SMD LED 1206(tentatively). The LED light should be turned on lasting 200–500 ms in less than 500ms whenever the processing system dictates that the users are in poor posture and remain turned off otherwise. The light should not be uncomfortably bright but needs to be visible to the users.

4.3.2. The LED light should be able to use the 3.3 V power supply(with modifications if needed, such as resistors to control amount of current).

4.4. Buzzer

4.4.1. The buzzer we will use is CUI CMT-1203-SMT(tentatively). The buzzer should be turned on lasting 200–500 ms in less than 500ms whenever the processing system dictates that the users are in poor posture and remain turned off otherwise. The noise should be gentle and distinct from any background noise.

4.4.2. The buzzer should be able to use the power line from the battery directly (with modifications if needed).

5. Enclosure

5.1. This subsystem is simply the enclosure that will encase all of the other subsystems except the stretch sensor because a majority of it sits outside the entire system, ideally this enclosure would be the size of a tic tac container if possible.

5.1.1. Requirement 1: The enclosure should be the size of a tic tac container or smaller, that would be of dimensions 4.45 cm x 7.3 cm x 1.59cm

5.1.2. Requirement 2: The material of the enclosure should be sturdy, non-flammable, light-weight, and safe to contain electronics

5.1.3. Requirement 3: The enclosure should be accessible for debugging/repairs if required

Risk Analysis

The block that will pose the greatest risk and difficulty will definitely be the stretch sensor, as it provides a secondary measurement that will provide sufficient data to determine if the user has deviated from their proper posture. The reason this block is the riskiest is because there is a lot of variability when it comes to human anatomy, everyone's upper back/shoulders are different, we need to create a variable design which can encompass this challenge and accurately develop an algorithm to distinguish between poor posture and regular breathing patterns. A stretch sensor is also volatile to external factors as resistance profiles can change with the environment. As a current standing value, stretching $\pm$ 3mm would indicate poor posture, without knowledge or testing of how feasible this is, this stretching could easily occur from someone breathing or bending over to pick something up. An acceptable tolerance would be that false-positives occur at a rate $\leq$ 1 per hour, at a sampling rate of $\geq$50 /s.

III. Ethics and Safety

Ethical Concerns

- E-waste from batteries and other electrical components is a concern.
- The product should be designed to work with diverse body types and clothing styles.

Safety Concerns

- If the device breaks, sharp edges or exposed wires could cause injury.
- The device should be durable enough to withstand drops and moderate stress.
- Battery malfunction could lead to a fire hazard. Fail-safes such as short-circuit protection are needed to mitigate risk of fires.

Citations and References

[1] “IEEE code of ethics | IEEE,” IEEE | Advanced Technology for Humanity, https://www.ieee.org/about/corporate/governance/p7-8 (accessed Sep. 19, 2025).

[2] “ICM-20948 | 9-Axis MotionTracking Device,” TDK InvenSense, https://invensense.tdk.com/products/motion-tracking/9-axis/icm-20948/ (accessed Sep. 19, 2025).

[3] “Choosing the best and safest battery for a…,” r/hwstartups (Reddit), https://www.reddit.com/r/hwstartups/comments/1dc0jle/choosing_the_best_and_safest_battery_for_a/ (accessed Sep. 19, 2025).