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Smart Vibration Band For Hand Fatigue

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Abstract : This Carpal Tunnel Syndrome (CTS) is a condition that affects both hand and wrist. It happens when the median nerve, which passes from forearm to palm, gets compressed at the wrist. The primary causes of this condition include tingling, hand weakness, numbness in hand and trouble in gripping the objects. The individuals with Carpal tunnel syndrome frequently feel uncomfortable when writing, which impairs writing quality and speed as well as causes early fatigue and frequent breaks during extended writing assignments. Due to the difficulties faced by people with Carpal Tunnel Syndrome encounter when writing, including hand pain and numbness, there is an increasing demand for assistive devices that can reduce stress and promote better writing practices. To address this, the proposed project offers a wearable band that detect the force of the individuals while writing. In addition to serving as a stress-relieving, calming massage, the device detects excessive force and alerts the user with a gentle vibration to encourage a lighter grip and help prevent further strain. Teachers, authors, students taking exams, and anyone else who writes a lot will benefit from this solution, as also those who are at risk of repetitive strain injuries. Because the band is so thin and light, it fits naturally and is comfortable enough to wear all day. Through this initiative, we hope to not only address pressing issues but also encourage providing regular, simple, non-invasive care will result in longer-lasting, healthier hands and stop the onset of chronic hand conditions.

***IndexTerms*– Wearable Device, Writing Comfort, Hand Fatigue, Behaviour Adjustment.**

I. INTRODUCTION

Writing continues to be important in both academic and professional environment. From taking notes in a classroom to important documents at work, writing plays a major role in both academic and professional life. While most of people don't think twice about how to hold a pen or how much force should one apply while writing leads to various problems. Eventually, the way of writing can actually create a significant effect on health of the hand. Writing for various hours or applying too much force can eventually cause pain or injury, even though it might seem like a simple daily task. Carpal Tunnel Syndrome (CTS) is one such serious condition**(**Khandelwal et al. 2016). It occurs when the median nerve in the wrist is compressed, typically as a result of prolonged pressure or repetitive hand movements, and results in tingling, pain, and numbness in the fingers. Writing becomes very serious for people with this condition. They might have trouble in holding the pen, experience ongoing pain, or need to stop writing frequently because of hand fatigue. In many situations, it may even impair their handwriting and lower their output (Chang, S. H et al.(2010). This is a serious issue, particularly for office workers, students, and anyone who spends a lot of time writing by hand. This project aims to address this problem by developing a wearable project that gives individuals immediate feedback when they apply more force while writing. This device can determine how hard the user is pressing the pen while writing, which is an efficient concept and also provide gentle vibration to alert the user to loosen the grip. This type of feedback promotes better writing practices and makes the user more conscious about holding the pen. A force sensor, microcontroller, vibration motor, and voltage regulator are all part of the wearable system. These parts are incorporated into a tiny strap where the force sensor is placed in the area where the user grips the pen and the vibration (Ebenbichler, G. R. et al. 1998). motor is placed anywhere the individual is preferring either in their fingers are in the palm of the user's writing fingers but primarily the index and thumb fingers. Therefore, this product combines engineering and ergonomic design to tackle a common yet often ignored health issue. According to the user preference it is made to be both comfortable and lightweight. It helps by offering immediate relief during activities that might otherwise worsen their discomfort. The force sensor continuously checks when the user writes. While the microcontroller gently alerts the user by providing vibration when too much of force is applied by the user. By reducing wrist and finger strain, this device makes writing more comfortable, especially for those who have CTS or are at risk of getting it. Professionals who must write for extended hours of time and students during exams or notes-taking sessions may find it especially helpful. The overall goal of this project is to solve a real life problem with basic technology. Combining comfort and utility, the design provides a useful result that blends with the individualities diurnal routine, making writing more comfortable and eventually securing the health of their hands.

II. STATE OF ART

Recent research has gone a long way to shed light on why and how writing leads to fatigue. Seo et al. (2019) found that continual grip pressures over around 35% of a person's maximum voluntary contraction speed the onset of muscle fatigue. Nakamura et al. 2021) showed clear patterns of pressure distribution changing as fatigue sets in, with compensatory reliance moving from intrinsic to extrinsic hand muscles for longer writing tasks. Conventional approaches to reduce hand fatigue have been mainly based on ergonomic modifications of writing instruments. In fact, for instance Chen and Wong (2020) evaluated 27 ergonomic pen designs

and demonstrated only mild improvements in subjective comfort with little effect on muscle fatigue overall. Other recent innovations, like the pressure-sensitive styluses developed by Patel et al. (2022) that deliver real-time visual feedback through associated applications to assist users in controlling grip strength. In the field of wearable technology, Yamamoto and Hiraki (2018) showed that rumble feedback of 200–250 ms duration creates a good user experience with high perceptibility and low-intrusiveness. Khatib and Rosenberg (2023) discovered that localized vibration alerts can create persistent behavior ranges that do little to break the user's writing cadence. For all of these advances, today's solutions still fall short. Nevertheless, the majority of these approaches still rely on custom writing tools, or ask the users to break their focus between writing and visual feedback. There still is huge power in merging comfy, easy-to-wear forms, custom pressure sensing, and gentle vibrating cues aula-winning trio that could fill the gaps of so many current interventions.

III. PROPOSED SYSTEM

A. SYSTEM HARDWARE DESIGN

To help reduce the discomfort and strain commonly experienced by individuals with Carpal Tunnel Syndrome(CTS), especially during extended writing tasks, this project introduces a smart, wearable solution. . The primary development of the system has been to combine force sensing and vibrating motors. The device is built with keycomponents that work together to monitor how much force the user applies while writing. Sensitive force sensorsare placed in pressure-prone areas like the thumb, index finger, and near the grip area of the pen. These sensorsdetecthow firmly the user is pressing and send continuous signals to a microcontroller. When theforce given by the user is beyond the limit that is set, the microcontroller immediately activates the small vibrationmotor, which provides the user a gentle feedback, encouraging them to ease their grip and also acts as an soothingvibration to reduce pain. This immediate response helps prevent poor writing habits, hand fatigue and reducesphysical stress on the hand and improves the concentration. To keep the system functioning smoothly, a voltageregulator ensures all parts receive a stable supply of power. Therefore overall hardware setup supports real-timecorrection and serves as a preventive tool for managing writing strain and reducing the risk of developing CTSrelatedsymptoms. Therefore, it is an essential tool in both academic and professional settings, where ergonomicrisks from pen and paper can pose serious problems.

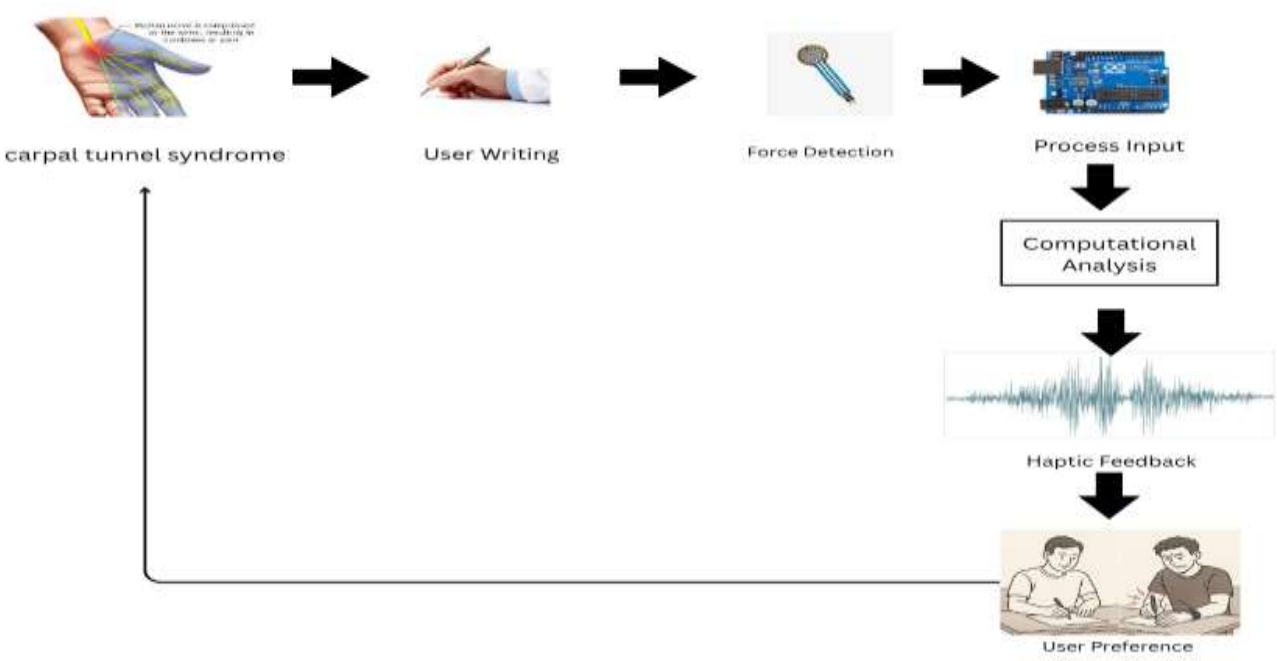

Figure 1.Block Diagram

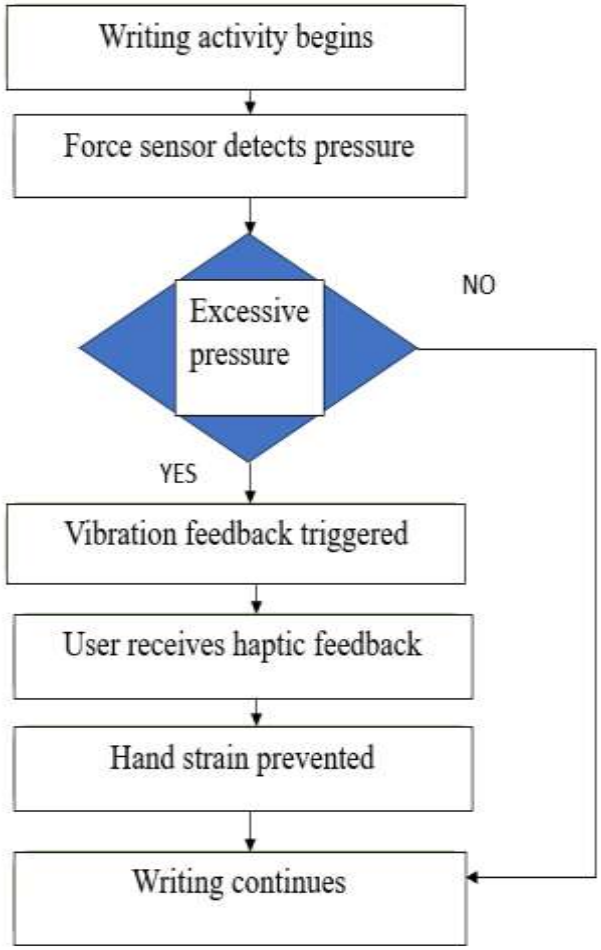

Figure 2. Work Flow

IV. PARAMETERS TO BE MONITORED

The wearable band effectively prevents strain associated with writing, particularly ailments like Carpal Tunnel Syndrome, crucial metrics are tracked in real time. The key parameter of the system is monitoring of the writing force applied, which is constantly assessed by adaptable force sensors located at the pressure-sensitive areas of the hand, such as the thumb, index finger, or the region surrounding the pen grip The force sensor can be fixed either in the thumb or index finger according to the user needs(Heller, B. W., et al. (2014). When the user writes, these sensors detect even minor changes in force, enabling the system to identify when force levels start to rise unexpectedly. When the system recognizes that the exerted force surpasses the established safety limit, the vibration motor is triggered. If not taken serious, and continues to write in regular bases, it may lead to long-term nerve irritation, joint stress, and muscle fatigue. Maintaining the force continuously without breaks, even if it isn't very high, can still be uncomfortable or raise the chance of injury. Therefore, one of the most important parameter is spotting potentially dangerous writing habits which is length of time spent applying force. This system not only used as an alert for the user but also provides a soothing massage for the user which prevents repetitive strain or inappropriate grip techniques. This feedback mechanism not only corrects writing mistakes but also encourages and sustains posture enhancements while writing. The system continuously monitors the intensity of the force. In addition to provide instant relief, this method reduces the likelihood of getting, chronic hand issues ad helps in raising awareness. The main focus is to slowly teach the user about more sustainable and health-focused writing techniques that will ultimately safeguard their hand muscles and nerves and increase the well-being .

V. RESULT AND IMPLEMENTATION

A compact, portable device that is designed using force sensors, microcontroller, vibration motor, and a voltage regulator. The smart vibration band for hand fatigue has been successfully designed, developed and evaluated showing a great potential in reducing writing-induced hand fatigue and promoting an appropriate hand posture during writing(Heller, B. W. et al. 2014). To measure the force exerted while gripping a pen, the force sensors were positioned in key regions of the hand that undergo the more strain during writing, like the thumb and index finger, as most individuals grasp their pens with these fingers. The system monitors the analog values from the force sensors to compare the input against a set threshold. The microcontroller immediately signals the vibration motor to apply haptic feedback (Prattichizzo, D. et al. 2017) to the user as soon as the exerted force exceeds this safe limit. The user was able to modify harmful behaviour by using this instant notification as a cue to loosen their grip and reduce writing force. When used frequently, In addition to relieving discomfort, the device aimed to improve ergonomics by retraining the user's writing habits. The system functioned reliably during the testing, by the user by precisely detecting force and giving timely feedback. Users reported feeling more conscious of their writing force, more concentrated in their work and found the vibration alerts helpful in loosening the grip and changing the position of their hands. According to the results, the device effectively detects excessive writing force and provides feedback based on the detected force, making it an useful tool for

preventing writing-related stress. This successful application shows that hardware can be used to create assistive wearables that promote good writing practices, especially for professionals and students who engage in prolonged writing works.

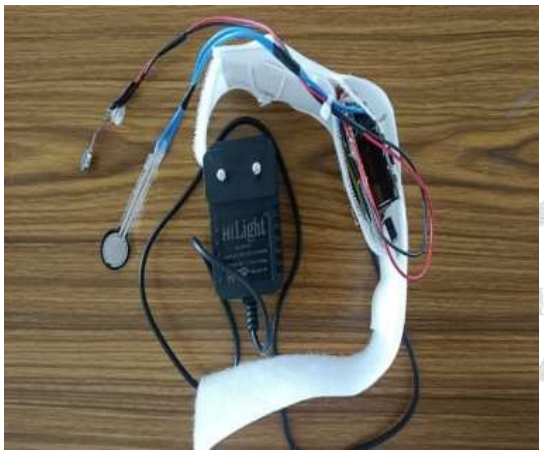

Figure 3. Vibration Band

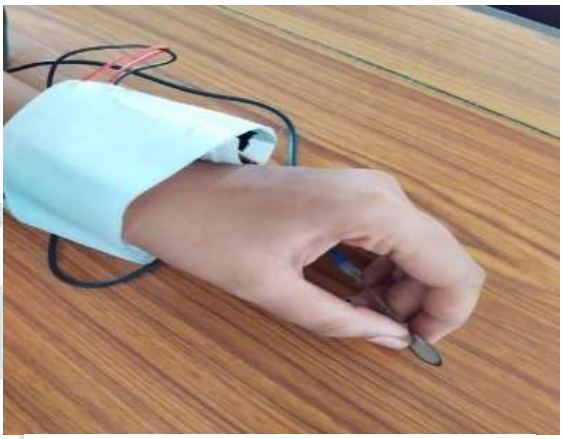

Figure 4. Force Sensor

VI. CONCLUSION

The wearable vibration band represents an innovative new tool to help fight the largely invisible threat of hand fatigue and strain from excessive writing force. This problem has become particularly acute among demographics such as students, office employees, creatives and individuals with repetitive motion injuries or other muscle-skeletal ailments, such as carpal tunnel syndrome. Central to the device's functionality is a real-time feedback loop. An embedded force sensor monitors the user's grip in real-time as they write(Heller, B. W., et al. 2014). When the band detects that you're bearing down more than you should, it signals you with a gentle buzz. In so doing, this response hopes to accomplish two primary tasks. Firstly, the vibration while writing, encourages blood circulation to the area and produces a relaxing effect on your muscles, offering immediate relief. Second, it provides very specific behavioral feedback mandating that the individual grasp the pen in a different way or position themselves differently when writing. Through sustainable practice of this degree of biofeedback, we are able to cultivate more ergonomic composing habits and prevent the onset of long-term injury. Communicating in a classroom, workplace, library, or lab, its small, light, and discreet design makes the device easy to wear. Unlike traditional, passive ergonomic interventions, this flexible, wearable solution offers a more active, empowering intervention that supports users' self-regulation to foster long-term hand health and comfort

VII. SCOPE FOR FUTURE WORK

The current system successfully implements a wearable band that detects excessive force and provides vibration feedback to reduce finger strain. The possibility for continued evolution from this version of the project is enormous, from tech, to ergonomics, to medicine, touching down in each of these fields with huge promise. Further improvements in ergonomics would include breathable, eco-friendly materials, with customizable attachments which helps in maximizing comfort for daily use. Future enhancements may include app integration for tracking individual's data, adjustable vibration levels according to the user, and machine learning to adapt to individual writing styles. Additional improvements to battery performance via incorporation of low-power or battery less components and wireless charging capability. Including other biometric sensors like ones capable of reading skin temperature and heart rate and even muscle tension would further contextualize and elucidate hand stress and fatigue.

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