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VIPR- Vibration Induced Parkinson's Relief

Anushka Sridhar

Abstract*: This paper describes VIPR, an inexpensive tremor detection and mitigation device to help Parkinson's patients. It is built using a Raspberry PI, an accelerometer, power switches and a wristband with rows of coin motors, and python code. More than 10 million people world-wide have visible symptoms of Parkinson's disease. There is no known cure for the disease and the annual cost for treatment is estimated to be >$50Billion. Whole body vibration therapy has been widely researched but is expensive and not easily available. This device fits around a patient's wrist and uses an accelerometer to detect the onset of tremors and turns on the vibrating coin motors in the wristband at different levels depending on the tremor intensity. The data is continuously logged and sent to a care giver via a SMART phone connection. The accelerometer in the device is used to measure the change in acceleration in X,Y, and Z directions every 0.2 seconds and the data is compared to a threshold value to determine if the movement is a tremor or not. Once its established that it's a tremor, a relay switch turns on the coin motors on the wrist. Data was collected on Parkinson's patients to establish the efficacy of the vibrating wrist band and the threshold. The band was found to effectively improve the motor response of the patients while performing simple tasks such as writing and moving objects. This inexpensive device was found to be effective and can be used to improve the quality of life of Parkinson's patients.

***Keywords*: Raspberry Pi, Accelerometer, Tremor Mitigation, Python.**

I. INTRODUCTION

Parkinson's is a disease that affects the brain and causes tremors, poor coordination, and problems walking and moving. Dopamine[1] is a chemical in the brain that helps pass messages to different brain parts. The cells that produce dopamine are damaged in patients with Parkinson's [2]. Without an adequate supply of dopamine, the brain cannot send and receive messages correctly. This disruption affects the body's ability to coordinate movement. By the time the symptoms of Parkinson`s are evident with deterioration of motor skills, 60-80% of the dopamine cells have already been lost. Some medicines available on the market can minimize the symptoms, but since there is no known cause for the disease, there is no cure for it either. There are five stages in the progression of this disease [3]

Stage 1 - The person experiences mild symptoms such as tremors or shaking in 1 limb

Stage 2 - In this stage person experiences symptoms on both sides of the body

Stage 3 - Symptoms get severe and include the inability to walk straight or to stand. There is a noticeable slowing of physical movements in this stage.

Stage 4 - Walking is limited, and further slowing of movement

Stage 5 - A person cannot take care of themselves and may be unable to stand. They would need constant one-on-one care.

Parkinson's disease may first cause physical symptoms, such as shaking, tremors, loss of fine motor skills, and problems with balance and walking. As the condition worsens with time, the same changes in the brain causing the physical symptoms could also cause symptoms that may be more cognitive in nature, such as memory loss, dementia, anxiety, depression, slow blinking, drooling, and difficulty swallowing. This disease could severely impact the elderly patient's quality of life.

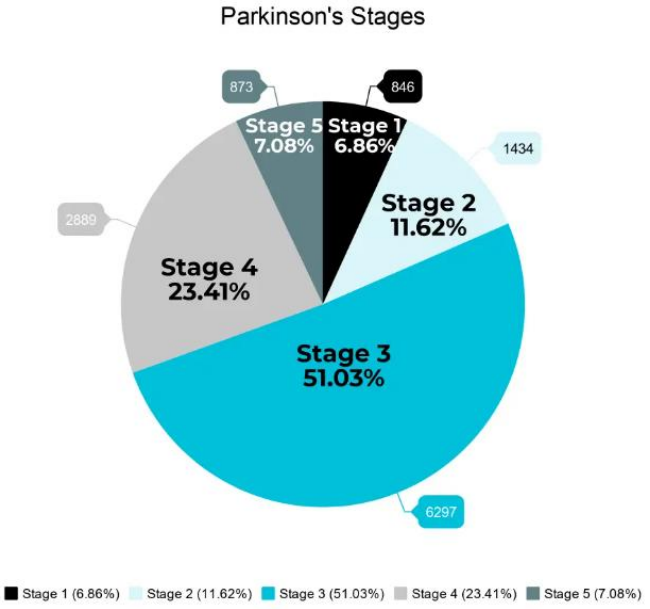

Figure 1: Stages of Parkinson's disease

Data source - *Parkinson's Foundation* [Graph]. (n.d.). https://www.parkinson.org/research/Parkinsons-Outcomes-Project/Demographics

Whole Body Vibration therapy [4] helps improve fine motor control and functionality among Parkinson's patients. The effects of a vibration-type stimulus in individuals with Parkinson's disease were first identified when patients displayed fewer symptoms while traveling on a train.

One theory suggests that with whole body vibration, neurons in the muscles get activated. Whole body vibration provides a mechanical oscillation of a specific frequency and amplitude along the horizontal axis and transmitted to the entire body [5]. While one maintains balance on the moving platform, whole body vibration provides stimulation that helps bypasses the Basal Ganglia circuitry, which is affected in people with Parkinson's disease.

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Essentially the vibrations help bypass the circuits that control the brain's response to Parkinson's and temporarily help alleviate tremors. This project aims to determine if the vibration could be targeted to the patient's wrist and see its impact on the fine motor skills of Parkinson's patients with tremors[6]. Further, could the effect of tremors be mitigated by detecting its onset and turning on the vibrating wristband?

II. HARDWARE DESCRIPTION

A. Overview of Raspberry Pi

A Raspberry Pi was used as the processor for this device prototype. It was chosen as it is compact and at he same time can process a large amount of data. Its built in Wi-Fi and Bluetooth capabilities allows it to be connected to a smartphone to pass data. The chosen Raspberry PI features a 1.2 GHZ Quad Core ARM V8 Processor, inbuilt Wi-Fi and Bluetooth, along with a host of HDMI, USB and audio ports

B. Other key Hardware components

Other key components used in the prototype were a 3D accelerometer, coin motors, relay switches, connecting wires, a lithium ion rechargeable battery and an Android Smart phone.

III. HARDWARE IMPLMENTATION

21 coin motors were laid on to the Velcro wristband and arranged in 3 rows. The coin motors were wired, threading the wires through to the other side of the band. The wires of the coin motors on each row are connected but separated from the other rows to ensure that each of the three rows of coin motors can be controlled independently. The 3D accelerometer is attached to the wrist band and to the Raspberry Pi with wires to appropriate GPIO terminals. The 2 relay modules are connected to a row of coin motors, the battery and the 2 GPIO pins of the Raspberry Pi, Finally the Raspberry Pi is coded using python code so that the accelerometer can accurately detect tremors and can activate the coin motors based on the processed data. If the tremor exceeds a certain threshold, the 1st relay switch is turned on, turning on 2 rows of the coin motors. After a certain time has elapsed and the tremor is still above the threshold, the 2nd Relay switch is turned on, activating additional coin motors and increasing the intensity of the vibrations. All contents other than the wristband with motors and accelerometer are placed in a waistband belt pouch.

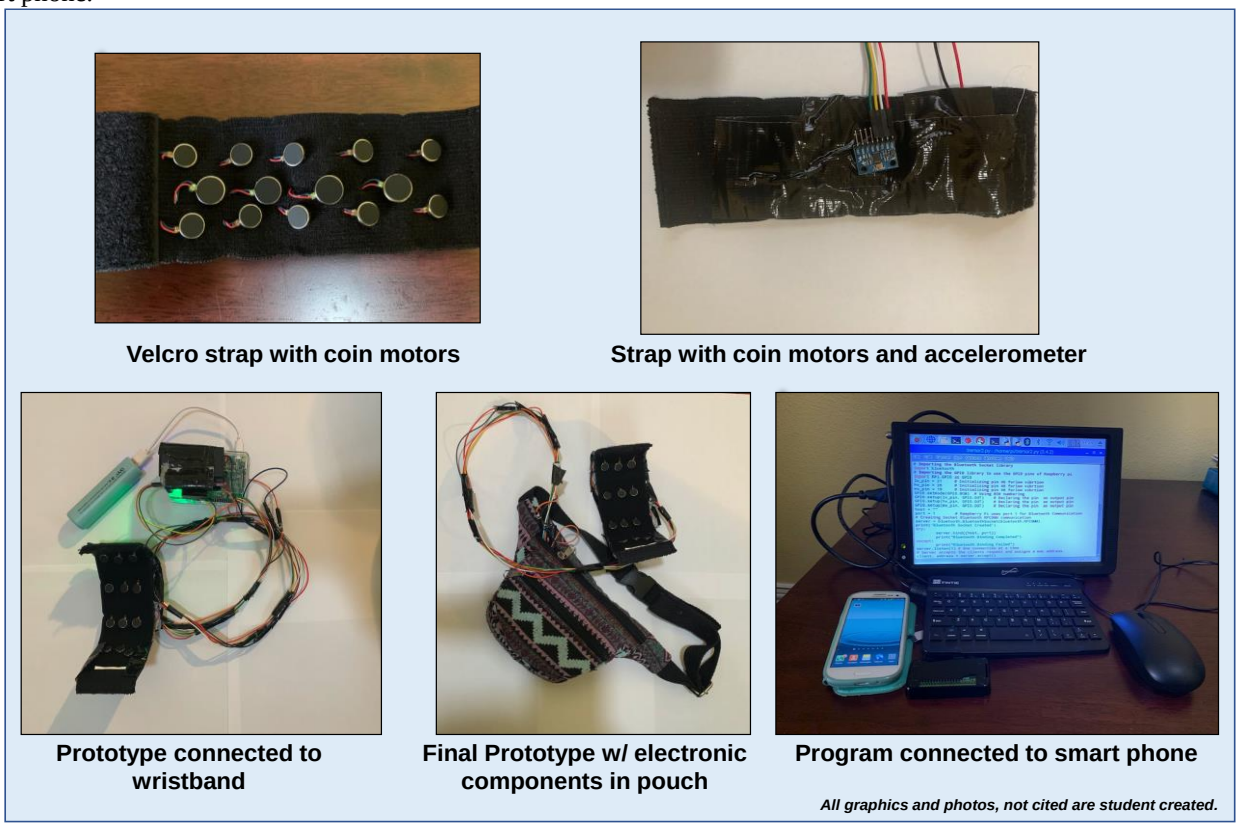

Figure 2: Prototype construction and setup. From top left clockwise- Coin motors in the band, Backside of the strap showing the soldered wires, Programing and transfer of data to smart phone, overall band electronics in a pouch.

IV. SETTING UP THE PROTOTYPE

The wristband of the VIPR is attached to the wrist of each participant. The first part is completed during the period when tremors are NOT present in hand of the participants. The device is activated so that the accelerometer can begin taking readings on the movement of the hand The accelerometer readings are recorded with the patient performing normal activities when tremor free. The same set of data is collected when the when participants' experience tremors. The analysis of the data showed that the optimum threshold value is obtained when the difference in accelerometer readings is measured every 0.2 seconds.

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When and the measured value exceeds the threshold value 10 consecutive readings it is clearly a tremor and not caused by any other routine activity. The 0.2 seconds interval is chosen as the frequency of hand tremors has been recorded at 5Hz in literature.

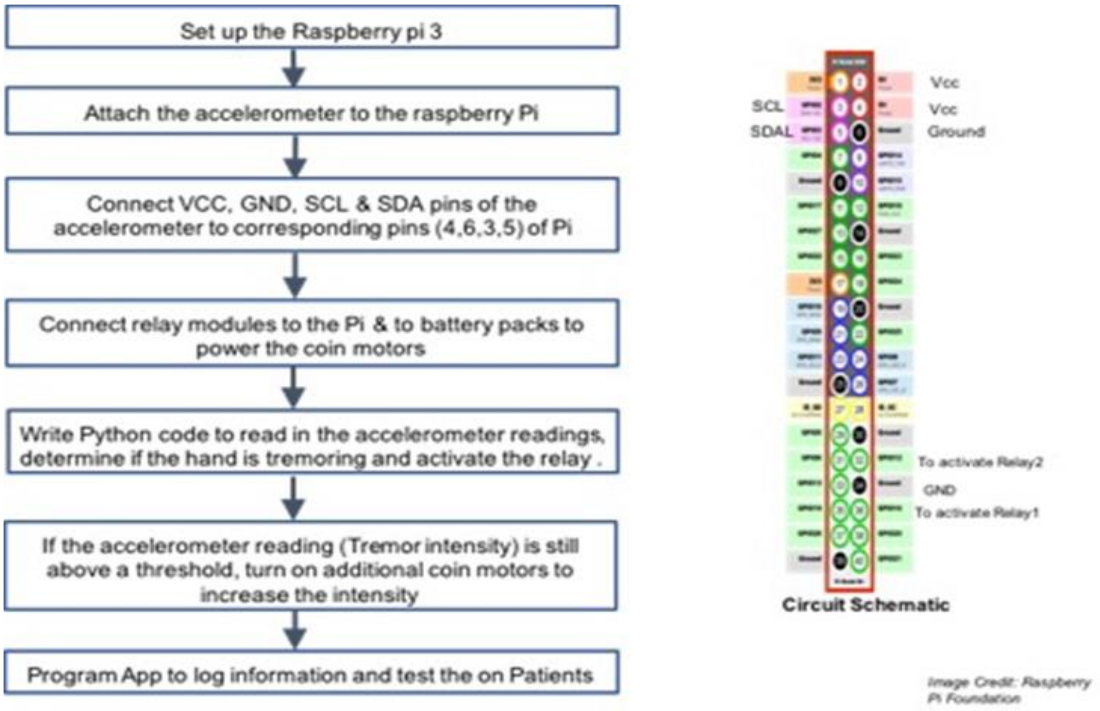

Figure 3: Step by Step Procedure to setup the hardware

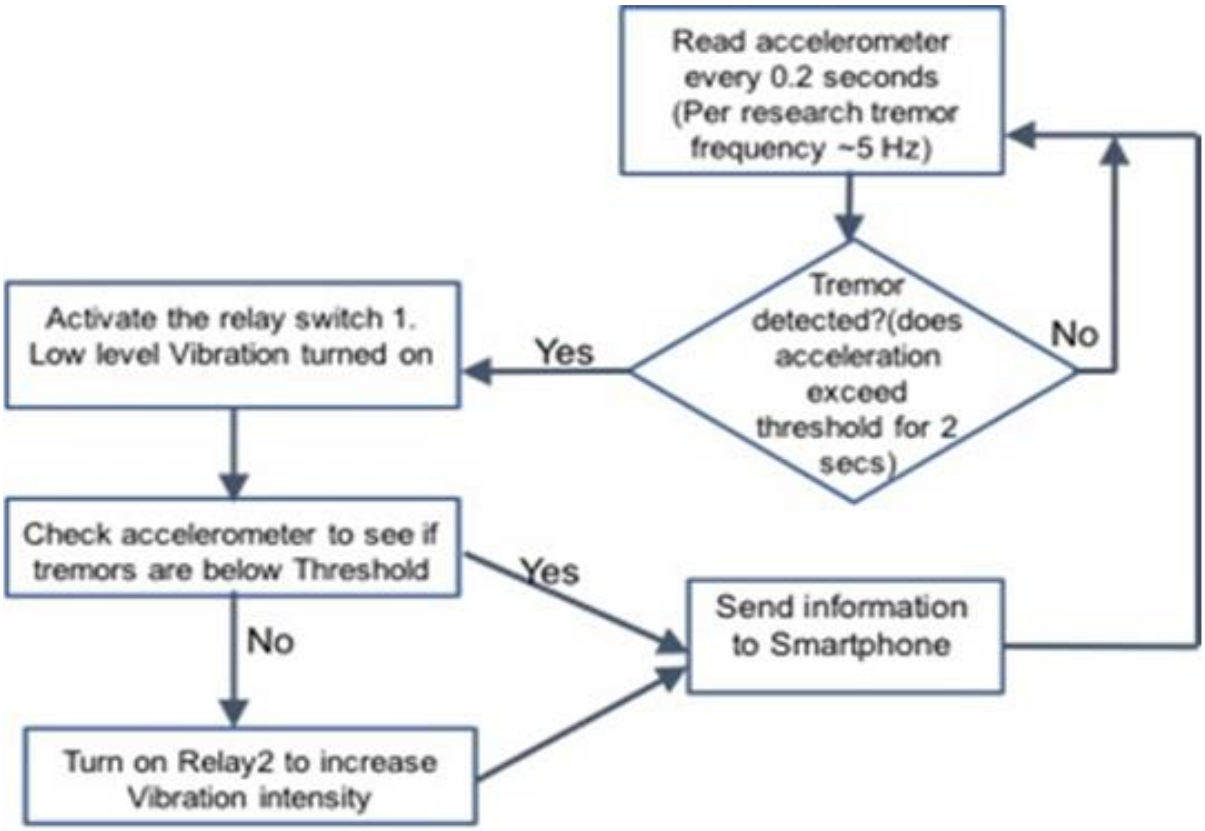

Figure 4: Program flow/Software logic

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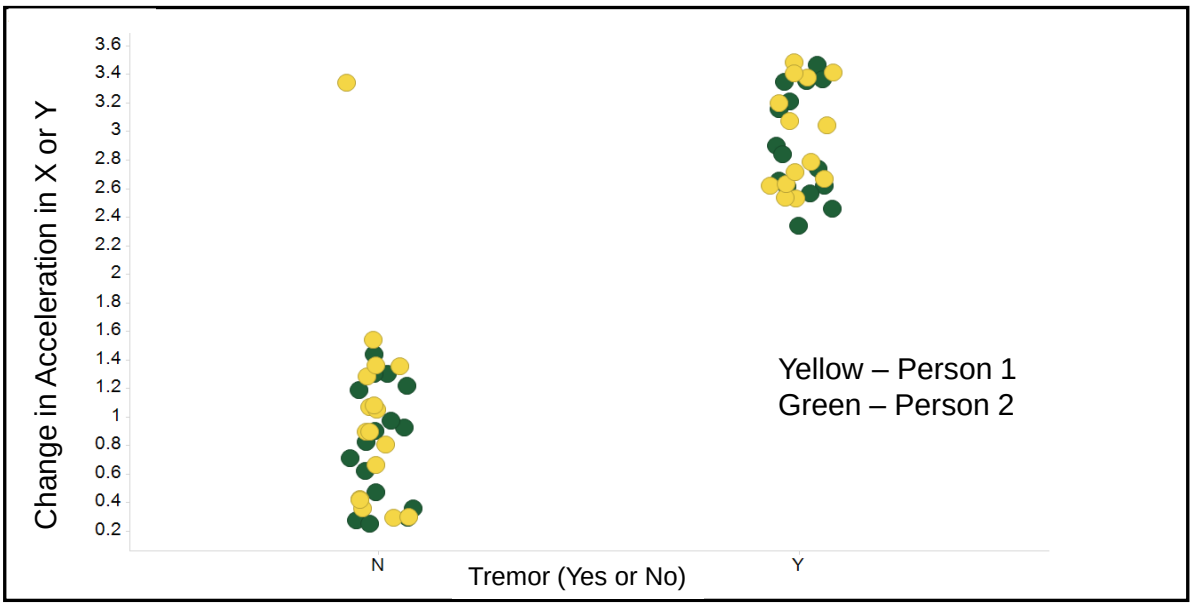

Figure 5: Plot showing the change in accelerometer reading vs normal activity or tremors. Multiple readings displayed. There is a clear separation in the 2 data sets showing that the accelerometer reading is >2 when a person experiences a tremor.

V. DATA/RESULTS

The built prototype works as designed. The prototype was tested extensively on 14 Stage 3 or higher Parkinson's patients. The 1st test was to see the impact the vibration level had on the tremor intensity (based on accelerometer readings).

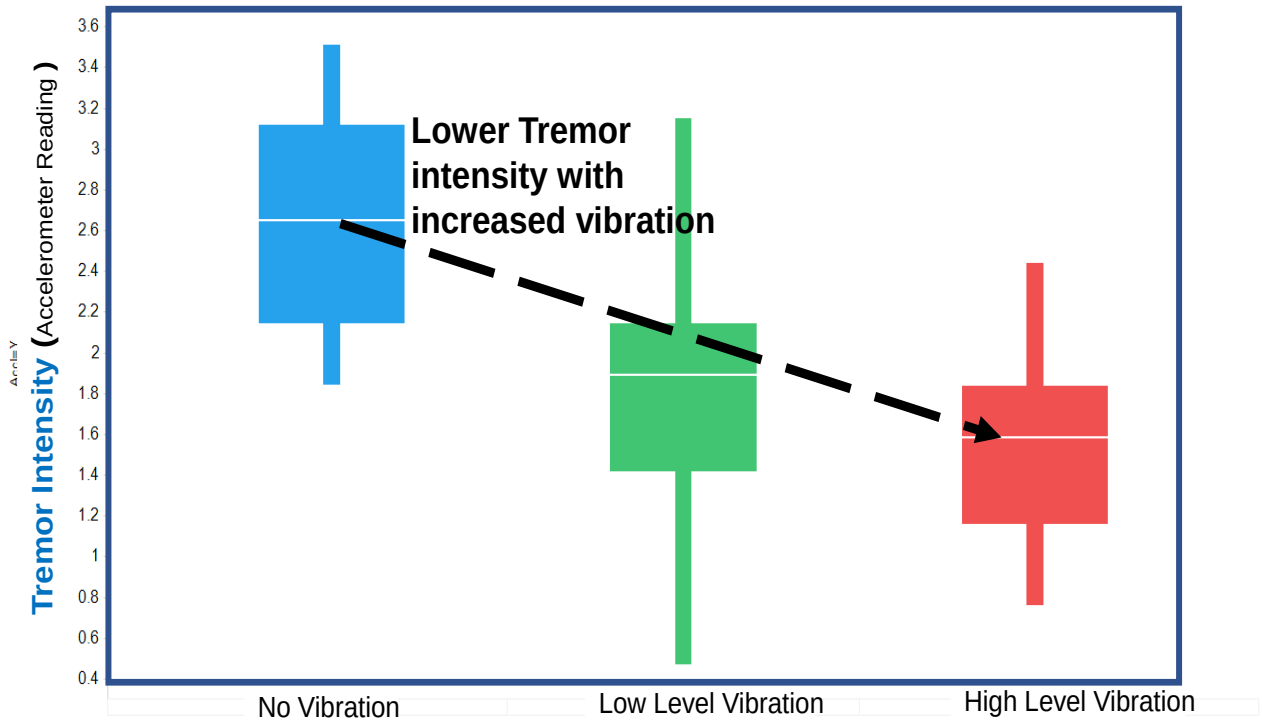

Figure 6: Effect of vibration intensity on Tremors intensity.

The tremor intensity of the patients decreases with increased Vibration intensity**.** The next test was to evaluate impact of this vibrating strap on fine motor skills such as writing and moving beads from one cup to another. Participants were asked to write the sentence, "The Quick Brown Fox Jumps Over the Lazy Dog, " as it uses all letters of the alphabet. The qualitive measure was determined by evaluating the number of words detected by the pen to print app. The quantitative measure of the handwriting is to measure the time it takes to write the sentence.

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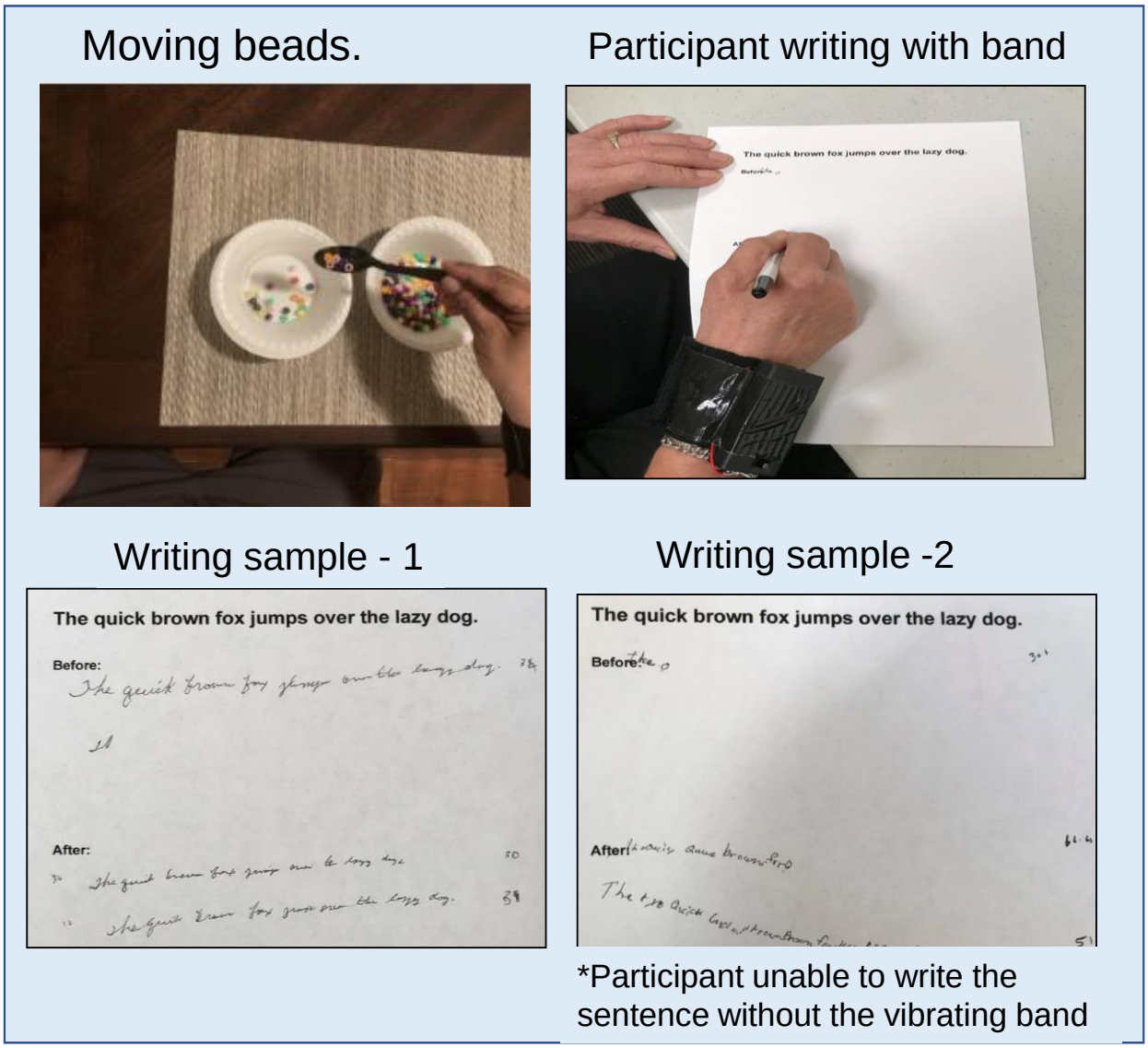

Figure 7: Data collection. Handwriting samples and movement of beads by Parkinson's patients with tremors, with and without the vibrating band turned on

Parkinson's patients asked to write a sentence or move beads. Activity done with no vibrations (control), and vibrations. Quantitative measures were time needed to write a sentence and time to move 5 spoons full of beads from one bowl to another. The qualitative measure was legibility of writing as determined by *Pen to Print app.*

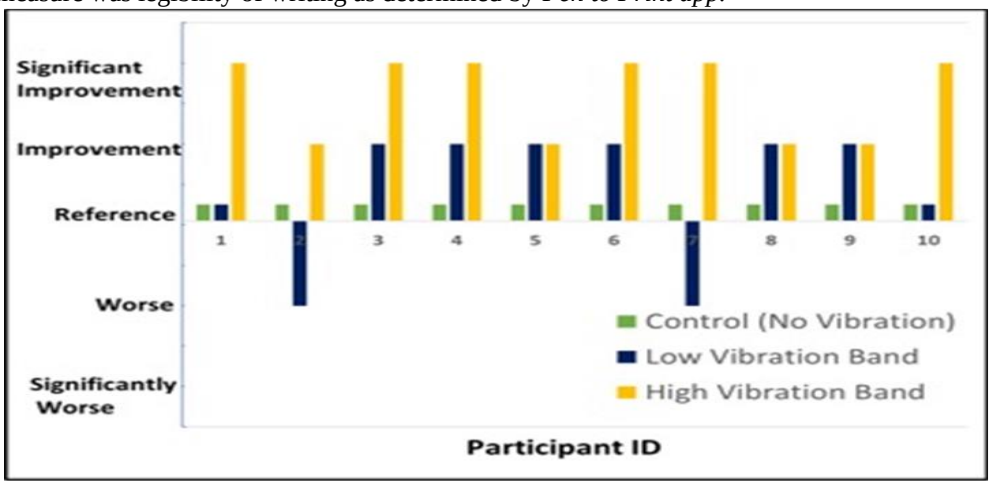

Figure 8: Impact of vibration level of the band on Penmanship. The qualitative measure was legibility of writing as determined by *Pen to Print app.*

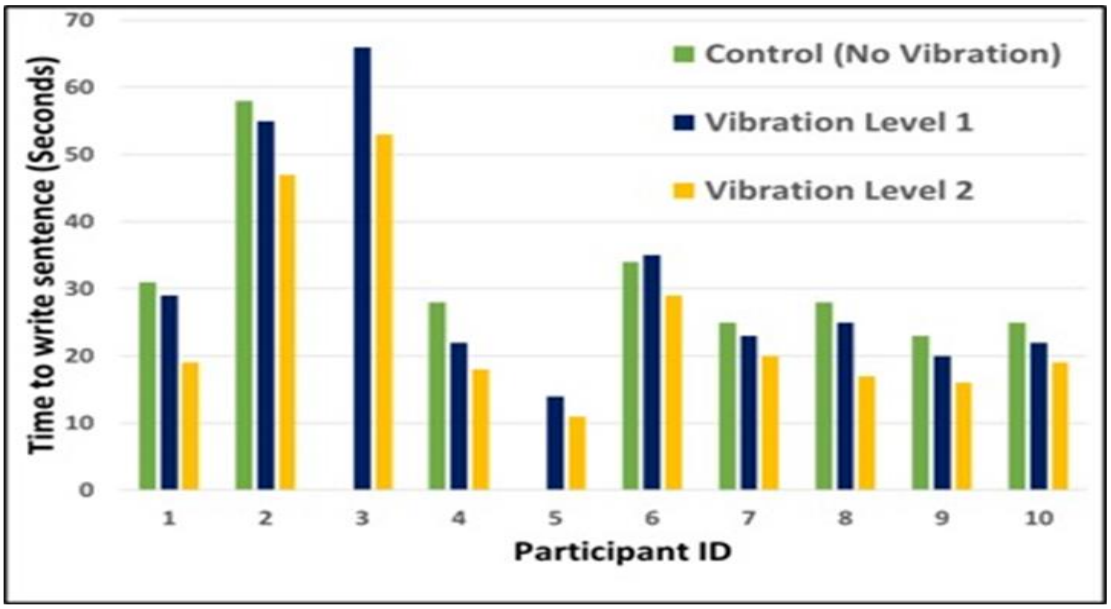

Figure 8: Impact of vibration on time to write. As the vibration level is increased there is a reduction in the time taken to write the sentence.

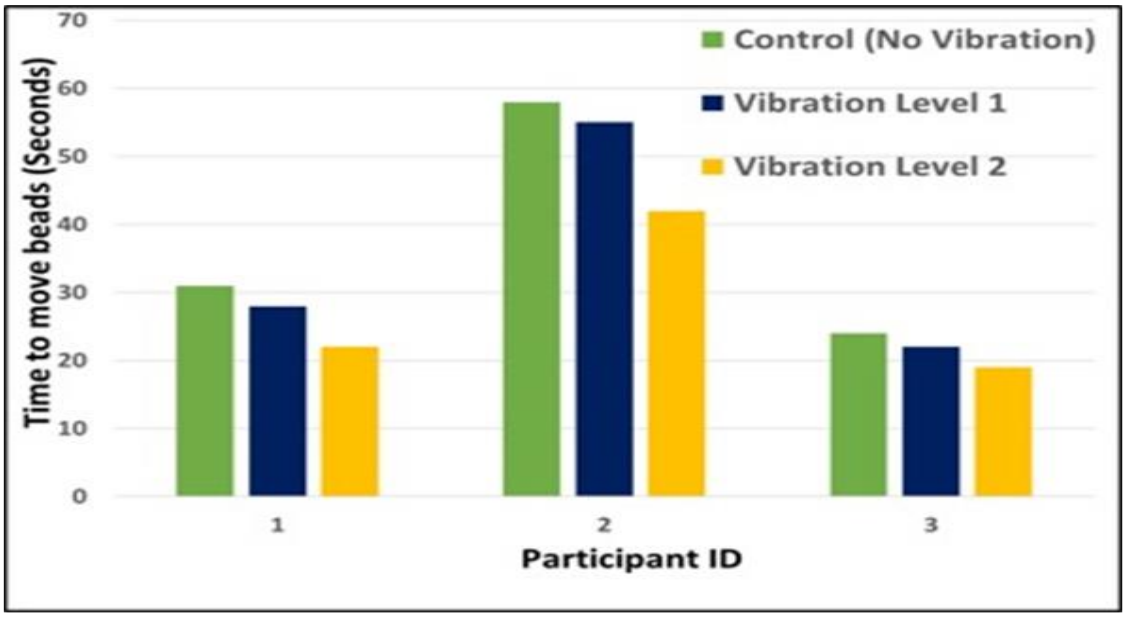

Figure 9: Impact of vibration on moving beads. When the vibrating band is turned on, the time taken to move beads is reduced.

VI. CONCLUSION

The built prototype works as designed. The prototype was extensively tested and found to work robustly across a variety of Parkinson's volunteers. The Threshold values to determine a tremor was found to be about 1.9 (acceleration times g). If the accelerometer detects a change in acceleration over 2 seconds that continuously exceeds a value of 1.9, the system registers that as a tremor and turns on the vibrating wristband. If the tremors still cause the accelerometer reading to exceed the threshold, the second set of motors turns on. It continually checks the accelerometer and if it falls below the threshold it turns the vibration off. The information on when it turns on is timestamped and sent to a Smartphone.

DECLARATION

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Ethical Approval and Consent to Participate	The article does not require ethical approval and consent to participate
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	I am only the sole author of the article.

REFERENCES

1. Cadman, B. (2016). *Dopamine deficiency: Symptoms, causes, and treatment*. Medical and health information. https://www.medicalnewstoday.com/articles/320637
2. Gavidia, M. (2020, November 3). *A review of stem cell-based therapies for Parkinson's disease*. AJMC. https://www.ajmc.com/view/a-review-of-stem-cell-based-therapies-for-parkinson-disease
3. *Statistics*. (2015). Parkinson's Foundation. https://www.parkinson.org/Understanding-Parkinsons/Statistics
4. King, L., Almedia, Q., & Ahonen, H. (n.d.). *Short-term effects of vibration therapy on motor impairments in Parkinson's disease*. (2013) . PubMed. https://pubmed.ncbi.nlm.nih.gov/20037223/
5. Koebel, A. *Whole-body vibration as a treatment for Parkinson's disease*. (n.d.). ClinicalTrials.gov. https://www.clinicaltrials.gov/ct2/show/NCT02306863
6. Zhang, H. *Project Emma*. (2020, April 27). Microsoft Research. https://www.microsoft.com/en-us/research/project/project-emma/

AUTHORS PROFILE

Anushka Sridhar is a high school student in the IB program. She has a strong interest in technology and entrepreneurship and hopes to work in a field that combines both of her passions. In school, she is a member of the National Honor Society, and an officer in the LASER club, which is responsible for organizing science fairs. Outside of school, she teaches taekwondo, is an avid participant of Destination Imagination, and is heavily involved at her local zoo. She is a member of the American Junior Academy of Science and has presented her research to scientists and peers across the world.