Precise Recording of Vibration Onset (Analysis & Logical Design)

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Activity Report

Abstract—Our cell phone vibration detector is designed to address a challenge in nerve rehabilitation at NCAN. Our Design Provides a solution using piezoelectric technology to detect cell phone vibrations with low latency.

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Index Terms—https://www.overleaf.com/project/64f9ff008351c9f6ab97e55a Cell Phone, Vibration Detection, Medical Research, Neurological Research, Brain Signals

1 The Problem

NCAN (national center for adaptive neurotechnologies) has asked our team to create a low latency, high precision, affordable device capable of detecting Vibration Onset within 5ms Precision, this will be compared against high precision lab equipment designed to do the same thing. With this project we hope to further neurological research by providing a cheap alternative to expensive lab equipment.

2 Design Constraints

In the design of the Cell Phone Vibration Detector, we are bound by several key constraints to ensure its practicality and accessibility.

- **Portability:** The Detector must be easy to hold and maneuver, ensuring accessibility for the users
- **Non-Intrusiveness:** the Detector must not require any disassembly or alteration of the phone.
- **Affordability:** Each Detector Must cost less than 100$
- **Latency:** The Detector must have Sub-5ms onset Latency.

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3 Design Alternatives

For the Detection of Cell Phone Vibration, there were Several Design Alternatives.

- Piezoelectric Detection: Using a Piezoelectric Vibration Detector
- Laser Vibration Detection: Using a laser and sensor to detect the vibration.
- Software Based Solutions: Using Software, such as a built in Vibration Detection Functions or Detection of battery life.
- Audio Detection: Using a small microphone close to the phone.

We decided to Go with the Piezoelectric Vibration Detector, as it is Cheap, Small, and has very low Latency.

3.1 Table

Our team created a small decision matrix. (Figure 1). The justification for the weights are as follows.

- Cost, 2 : Cost is highly important as it directly impacts the production expenses.
- Size, 4: Smaller components allow for more compact Design.

A1 | fx Criteria

	A	B	C	D	E	F
1	Criteria	Weight	Piezoelectric	Laser Detection	Software Solutions	Audio Detection
2	Cost	2	5	2	5	5
3	Size	4	5	2	5	3
4	Latency	4	5	5	2	3
5	Reliabliity	4	5	5	2	3
6	Total		70	52	46	46
7						

Figure 1. Enter Caption

- Latency, 4: Low latency ensures real-time response, crucial for detecting phone vibrations promptly.
- Reliability, 4: The reliability of the detection method is critical to avoid false alarms or missed vibrations.

4 Proposed Solution

Our solution involves using a piezoelectric sensor to measure vibrations. We'll connect this sensor to a microcontroller that will process the data coming from the piezo. When the microcontroller detects vibrations, the microcontroller will output a high voltage signal. When there are no vibrations, it will output a low voltage signal. To keep everything compact and portable, we'll encase the sensor and microcontroller in a 3D printed box.

4.1 Engineering Diagram

Figure 2 shows a prototype design of the device

4.2 System Requirements

4.2.1 System Users

This device will be used primarily by nerve-injured patients and healthy patients, to compare the nerve-injured patient's brain's response to a non-nerve-injured patient's brain's response.

4.2.2 Functional Requirements

1) **Detect vibration:** When the phone vibrates, the sensor will send voltage signals to the microcontroller.
2) **Precision:** The microcontroller detects the onset of vibrations within a 5ms accuracy window and outputs a digital high voltage.
3) **Noninvasive to the phone:** The device cannot intrude into the phones hardware. It must seamlessly work with a phone without taking the phone apart.

4.2.3 Non-Functional Requirements

1) **Portable:** The device must be handheld and portable.
2) **Budget:** The device must cost less than approximately $100 per device.
3) **Accessibility:** The device must be easy to hold and use for anyone, especially those with dexterity problems.

4.3 Justification

Piezo electric sensors offer high sensitivity to subtle vibrations along with fast response times in the millisecond range, making them well-suited for phone vibration detection. Piezo sensors are also relatively inexpensive and easy to integrate into circuits and microcontrollers. Additionally, they consume little power, and resist noise in chaotic environments. Finally, piezo materials are highly durable for long-term use. With this in mind piezo electric sensors are an excellent choice for phone vibration monitoring versus other alternatives.

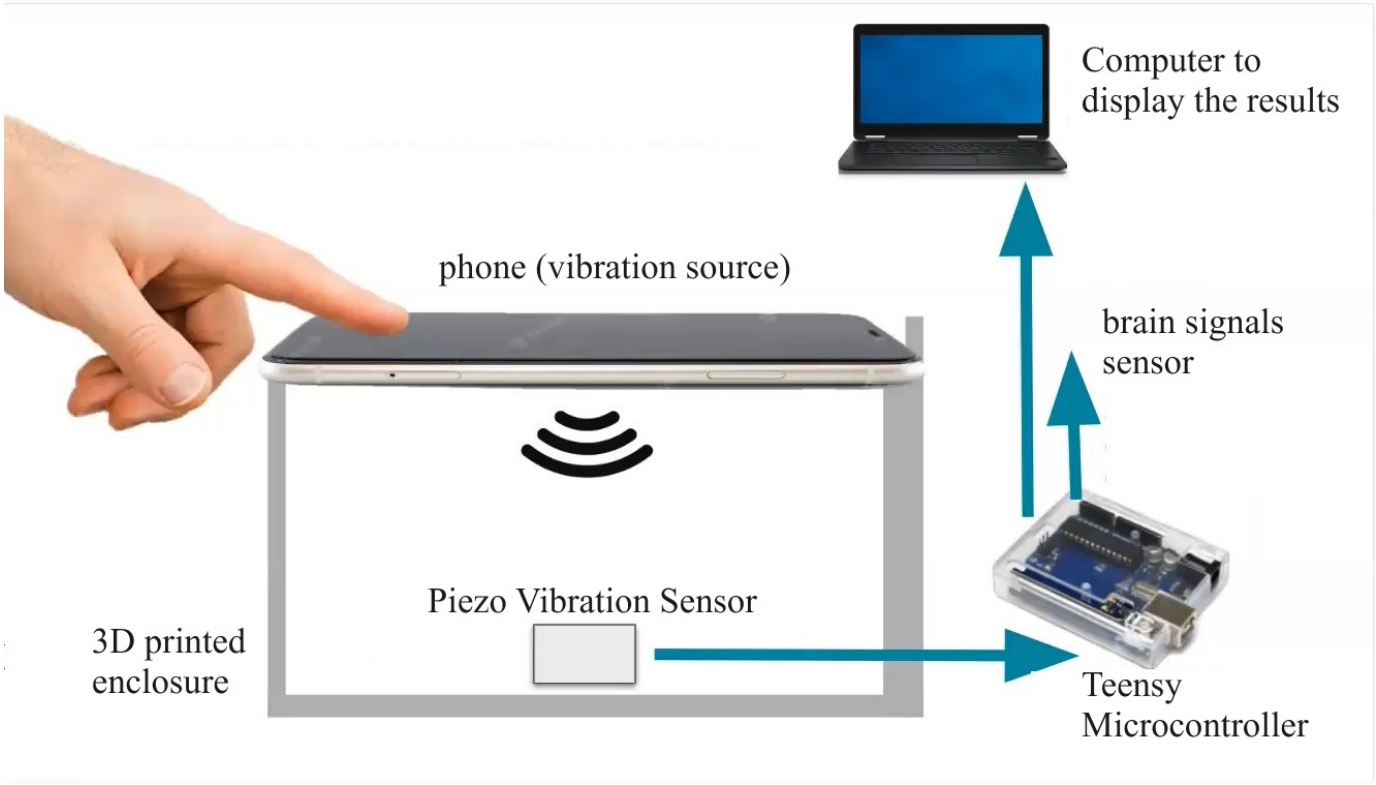

Figure 2. System Diagram

4.4 Ethical Concerns

- Data Privacy Issues : Any identifiable user data collected like phone numbers should only be obtained through informed consent. Data should be anonymized if shared publicly.
- Security Concerns : Ensuring secure data transmission between the Arduino, phone, and laptop to protect against unauthorized access. Updating software for vulnerability patches.
- Potential Harm : The system does not pose a threat of any physical harm or damage to users.
- System Misuse : Establish legal consequences for misuse of the system, including penalties for unauthorized access or data manipulation. Authenticate users and monitor for misuse.

5 Initial Prototype

Since this is the first year of this capstone, we are lacking an initial prototype.

5.1 Semester Goals

At the of the semester, the plan is for the completion of the wiring, and coding for the vibration detector, rendering it fully operational and poised for testing.

5.2 Year Goals

We anticipate the successful completion of the vibration detector, which will be fully assembled within a 3D-printed casing. Furthermore, testing will be conducted to ensure the device's functionality, accuracy, and reliability.

5.3 Work Responsibilities

- **Daniel Brown:** Archivist
- **Nasser AL-Maskari** Treasurer
- **Muhammed Shuaib:** Point-of-contact
- **Md.Sadman Kabir** Editor

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