Vibration Device for Quantification of Neuropathy

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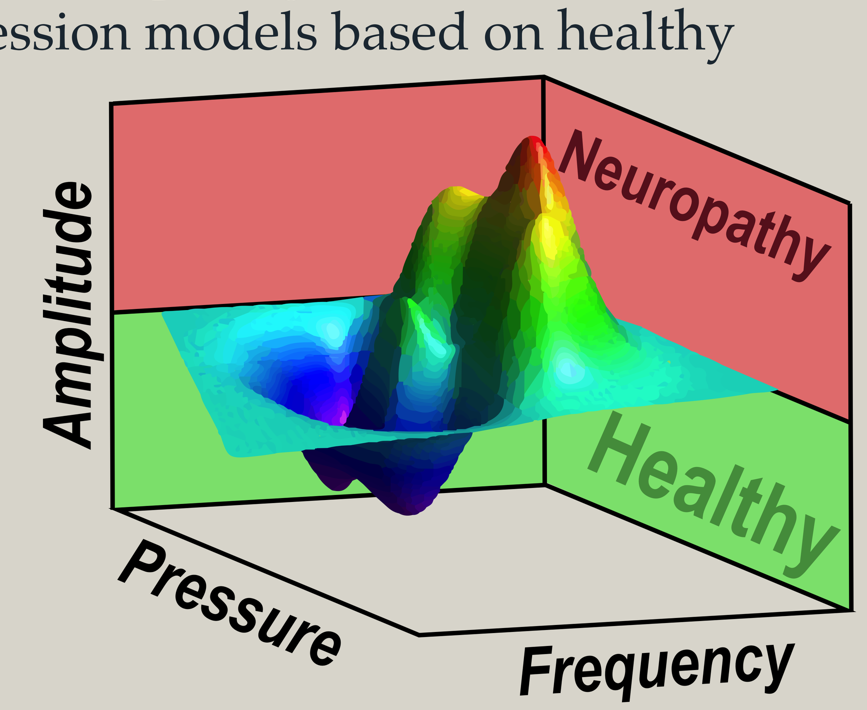
Problem Statement

Peripheral neuropathy refers to nerve damage located in the extremities that creates a loss of sensation in vibration, pain and temperature and increases risk for falls, foot ulcerations and amputations [1]. Caused by diabetes, toxins, alcohol and smoking, neuropathy affects 40 million Americans and can reduce their quality of life by 50% [2]. To detect neuropathy, the medical field uses a tuning fork test, which involves hitting a 128Hz tuning fork against a surface and then making contact with the patient's skin to subjectively determine if they have vibration sensation. This tuning fork test is inconsistent and provides no way to quantify what a patient feels. Research suggests that vibration frequency, pressure, and amplitude may all provide crucial correlations that can monitor and detect the disease, leading to new treatments and evaluation [3].

Our Mission

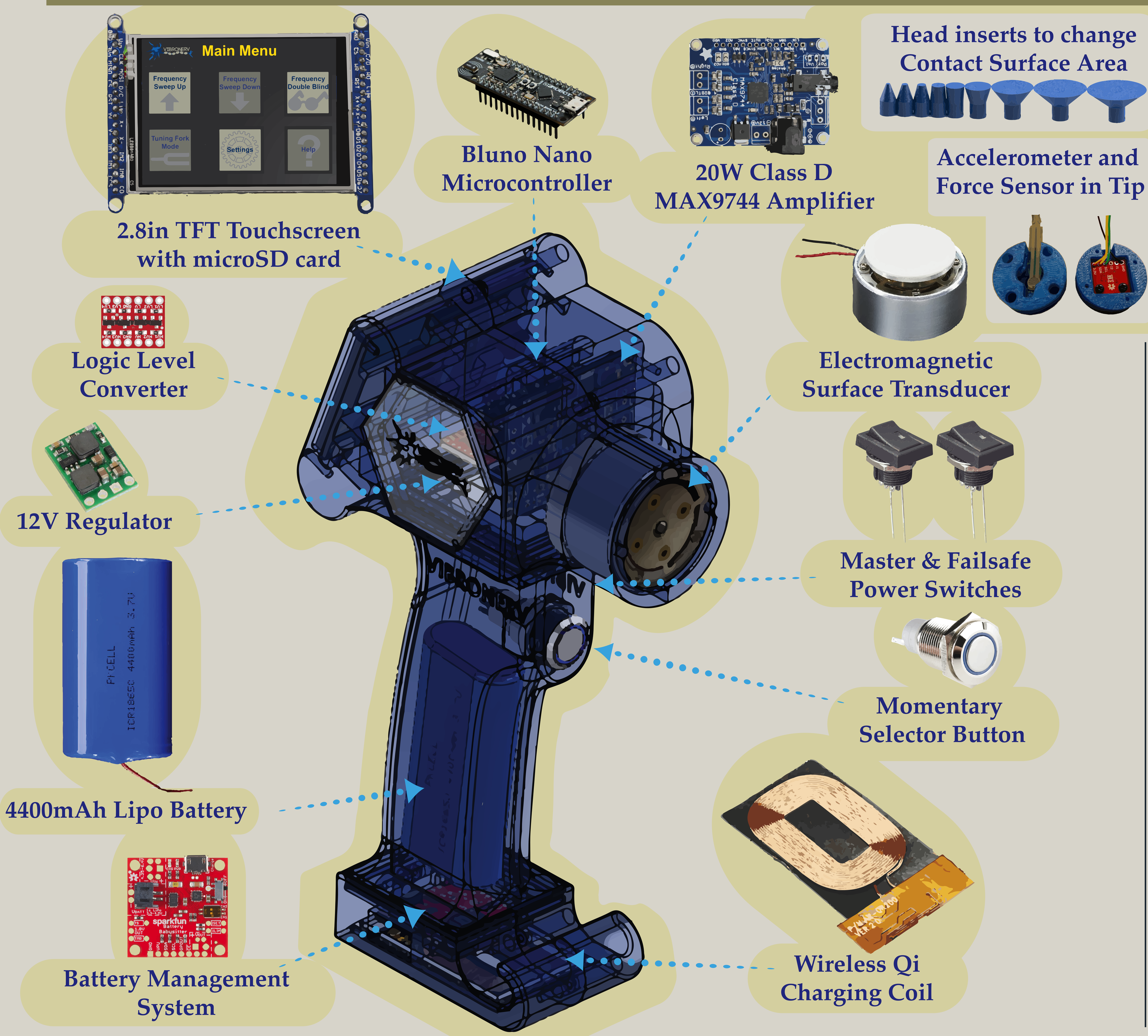
Our goal is to create a device that quantifies the range of vibration frequencies, pressure and amplitudes a patient can feel, known as the ***Vibration Perception Threshold (VPT)***. Comparing 3-dimensional VPT's over time to regression models based on healthy patient populations allow the device to be used on patients to quantify the severity of their condition and monitor disease progression.



Constraints | Deliverables

- Multiple Frequencies → 2-2000Hz Frequency Range
- Variable Amplitude → Increasing/Descreasing
- Variable Pressure → 5-1000mm^2 contact/Force sensor
- Time Efficient → 3 minutes per test
- Low Cost → < $300 per unit

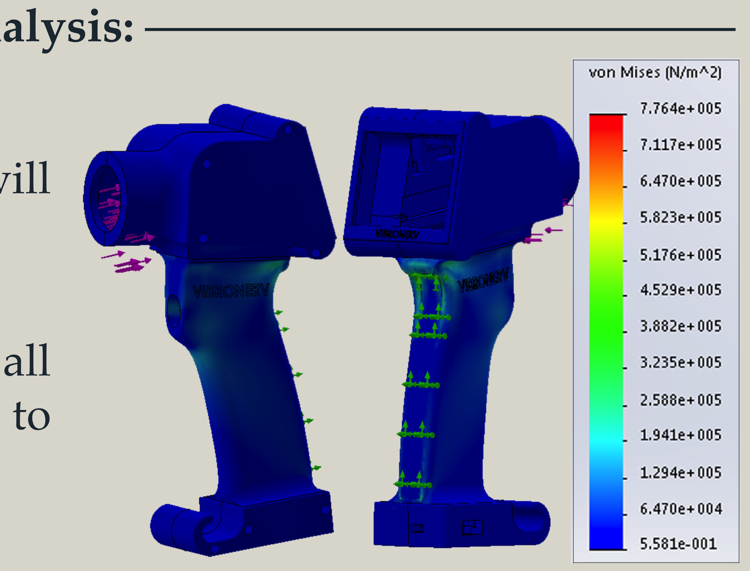
Design and Analysis



Stress Analysis:

Hypothesis: Our device structure will withstand a force of 10N at the tip.

Results: No critical deformation and all force localized in crux of hand to reduce user fatigue.



Vibration Analysis:

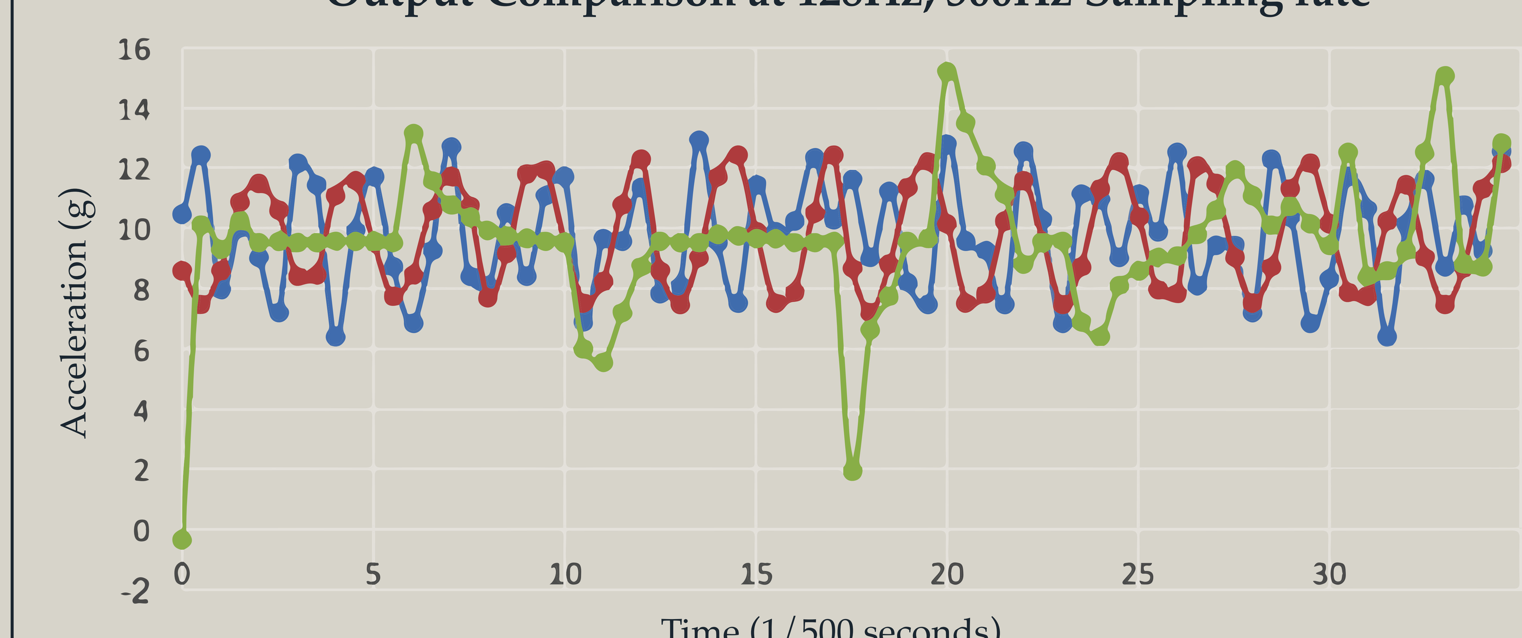
Hypothesis: The RMS percent error for 128Hz vibrations from our microcontroller should be lower than the tuning fork's when compared to a precise waveform generator.

Root Mean Square

$$RMS = \sqrt{\frac{\sum_{t=1}^{T} A^2(t)}{T}}$$

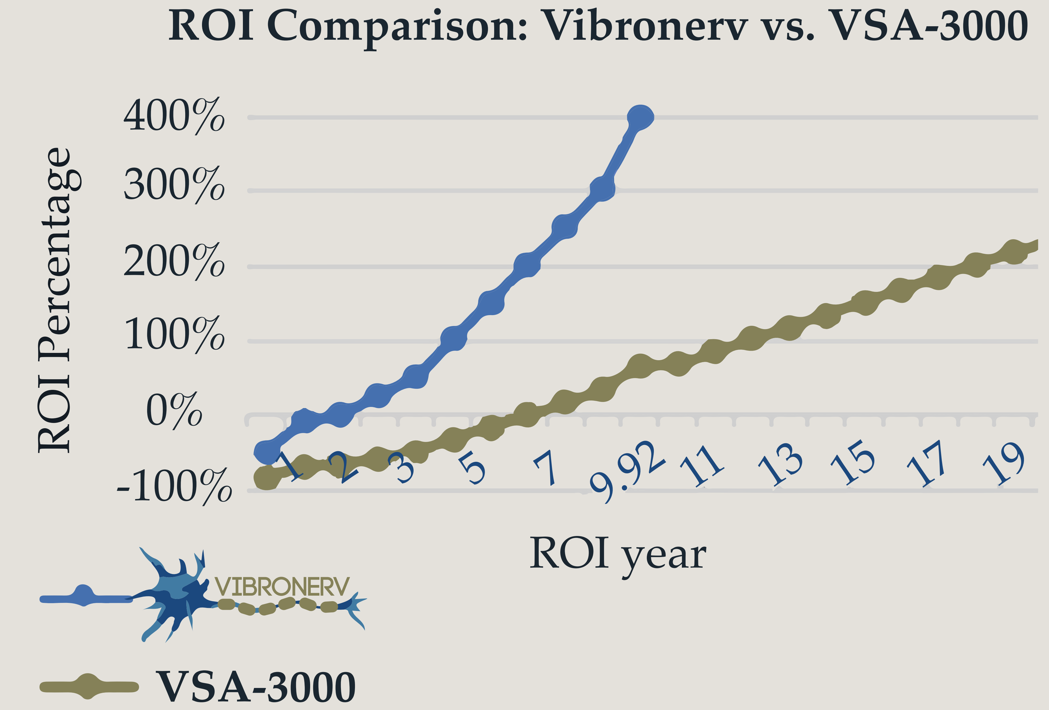
	RMS	Standard Deviation (from generator)	Percent Error
VIBRONERV	9.9461	0.0505	0.5%
Tuning Fork	9.7531	0.1425	1.45%
Waveform Generator	9.8956		

Output Comparison at 128Hz, 500Hz Sampling rate



Financial Analysis

ROI Comparison: Vibronerv vs. VSA-3000



- Device Lifetime is ~13.98 years with 10,000 tests per year.
- Monetary return observed after 5 tests.
- ROI of 236,330% over device lifetime.
- 4 times reduction of unit cost when scaling production to 21,000 units and printing custom PCB for electrical components.
- Significantly better ROI compared to VSA-3000 biothesiometer

Future: Clinical Pilot Study

- UCSF Fresno with Dr. Mark Stecker
- 20 neuropathy patients, 20 healthy patients
- To determine device's effectiveness
- Data collection of 3-dimensional plots to build trends for physician diagnosis

References

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[2] Sadosky, A. et al.. Economic burden of neuropathic pain in the United States: BEAT neuropathic pain observational study. The Journal of Pain, Volume 14 , Issue 4 , S13
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