Teeth Grinding Detection and Intervention Using Bone Conduction and Wireless Networks

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***Abstract*—This report represents all work done and evaluated as well as a future work for designing the device for detection and intervention of teeth grinding. This is very common issue which remains undetected and affects 10% of population. Work achieved in this report is showing that controlled signal can be detected using piezoelectric sensor through bone conduction leaving next step to focus on determining the frequency range of teeth grinding.**

I. INTRODUCTION

Bruxism (colloquially known as teeth grinding) is a common and damaging parafunctional habit that affects many people across the population and is responsible for mild to severe damage to teeth and jaws. For many, bruxism occurs during sleep, and thus an effective solution is available in the form of dental guards. However, this solution is ineffective in remedying bruxism for autistic children. A symptom of autism is to repeat motoric acts habitually and much more often than a typical adult would. Thus, the damaging effects of bruxism are greatly increased. To add to the problem, many of those with autism are aversive to invasive intervention, such as dental guards, and cannot be simply be notified of grinding and told to stop.

Our proposed solution to the problem of bruxism in children with autism is a non-invasive, aesthetically benign electronic wrist detector. The device would detect teeth grinding and provide instantaneous wireless feedback to the phone or computer of a responsible guardian. The medium by which this detection occurs is bone conduction. The simplified theory applied in our realization is that the strong signal created by teeth grinding can both be heard (transmitted through the air) and transmitted through the bones, which is a demonstrably powerful acoustic conductor. By placing a device at the wrist, with a proximity to the radius bone, the specific signature of grinding teeth can be detected as it propagated through the skull down through the arm.

Similar devices have been produced, which demonstrate the same technology, but with the inverse goal in mind. Sound is produced and propagated through the bones to the ear, allowing those who are hearing-impaired to detect sound by stimulating the eardrum directly. In realizing this project, we will take a similar approach, utilizing common commercially available components and software methods to verify the validity of hypothesis.

II. DESIGN AND RESULTS

The system consists of several cascaded stages. Analog circuitry starts with a piezoelectric sensor which is amplified through an instrumentation amplifier and DC decoupled before being input to the microprocessor. The microprocessor uses its embedded Analog to Digital converter (ADC) to collect data at an intrinsic sampling frequency. For debugging purposes, the data is transmitted to a computer over its Universal Synchronous/Asynchronous Receiver/Transmitter (USART) system. The USART module is characterized by a baud rate for transmission. The baud rate (in bits/second) must be at least 10 times greater than ADC sampling frequency (in samples/second) to achieve enough conversion–transmission relationship. Data is sent to a data file using by way of a USART terminal and processed in MATLAB.

The sensor used is a piezoelectric vibrometer with model number LDT1-028K and the microprocessor used is ATMEL Xmega128AU. Sensor is a laminated piezo film element which is designed to respond effectively on bending and vibrations. Piezoelectric materials produce electric polarizations when a strain is applied, usually produced by mechanical force [4]. The working principle is that vibration of the bone could be detected and sensed by the sensor as the mechanical wave passes through the piezoelectric sensor.

The bone conduction theory had to be verified. To examine the behavior of the sensor in response to signals from bone conduction, the microprocessor replaced the oscilloscope as seen in *Figure 1.*

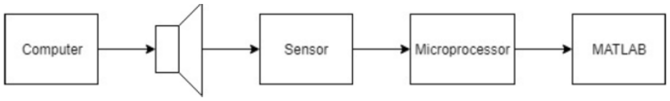

Figure 1: Setup used to verify bone conduction theory

III. RESULTS

Testing is done for following case for a duration of approximately 5 seconds:

A. Covic is a PhD student and Dr. YK Yoon is a professor at Department of Electrical and Computer Engineering at University of Florida, Gainesville, Florida.

a. Sensor taped with medical tape over all its surface on the top of the hand, 100 Hz signal applied through the speaker touching pointing finger alternately on and off.

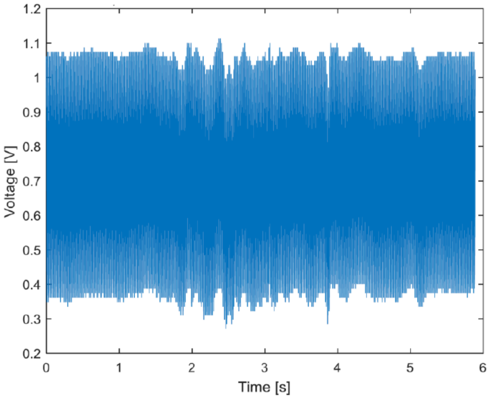

Figure 3. Experiment a.

IV. EVALUATION

Figure 3 shows the graph when sensor is taped on the top of the hand, at very flat area, keeping the sensor flat as well. Changes on the graph do not visually occur in frequency, but in amplitude. The speaker was on and touching the pointing finger during time periods: 0s - ~1.5s, ~5.2s-end, while for the rest of time, speaker was on and not touching pointing finger. The influence of 60 Hz frequency is very large. It can be seen in the FFT graphs in *Figure 4 (a)* produced by MATLAB code. The FFT is produced on the first 5000 samples, which corresponds to approximately first second of the experiment with the goal to show the 100 Hz peak in period when speaker was touching finger certainly. Graph in *Figure 4 (b)* shows large 60 Hz peak, with smaller peaks at its harmonics. When it is zoomed, as in *Figure 4 (b)*, a minor but important and promising peak is recognizable at 100 Hz.

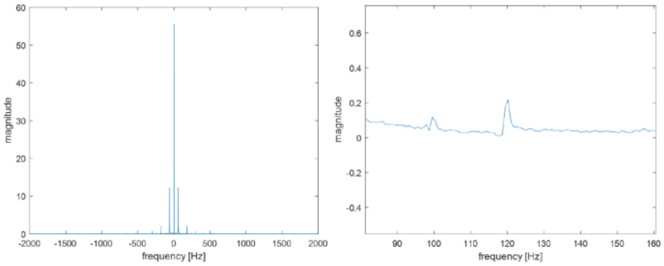

Figure 4. *(a) FFT* *(b) zoomed in FFT.*

V. CONCLUSION

Bone conduction is verified through the experiment shown in *Figures 3*. The length of the sensor is 41.40 mm and width of the sensor is 16.26 mm, which is very large sensor to be placed flat on the wrist. When piezoelectric sensor is bent, it produces DC voltage, which results in DC offset. DC offset is the reason for saturation read by microprocessor.

To filter out large DC offset, signal must be DC decoupled. The setup used in this experiment has decoupling capacitor included in circuitry, but the capacitor value probably was not large enough to filter DC offset completely. So, to solve this problem, larger capacitor than 0.1μF should be used. Additionally, the eventual band pass filter will further reduce any DC offset

VI. FUTURE WORK

The next goal of the project is to determine the frequency band for teeth grinding. With the knowledge of exact frequency bands, the sensing circuitry can be tuned to amplify these bands and eliminate all others.

Based on the physical dimensions of a tooth, the mechanical resonance frequency should be in the ultrasonic range. The frequency components in this range should be the largest. Additionally, these frequencies (40kHz-60kHz) are far away from the 60Hz noise and its harmonics, so this noise should be greatly reduced. To investigate this frequency band, an ultrasonic microphone will be used to determine the sonic signature of teeth grinding.

Once the operating frequency band is determined, the sensing method will be reinvestigated. Sampling and transmitting data at a high enough rate to recreate/analyze the ultrasonic sound will add additional power requirements to the system. To mitigate this issue, the first-choice setup will pass the ultrasonic sound through a bandpass filter to isolate only the bands of interest. These bands will then be rectified and averaged to create a DC signal which is a measure of the ultrasonic energy in those bands. With this method, the microprocessor will sample the microphone at a much lower rate. This method can only be used if the ultrasonic noise is low compared to the teeth grinding signal

VII. REFERENCES

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