The Use of Vibration to Neutralize the Parkinson Disease Hand Tremor

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Abstract *- Today there are some treatments available for the Parkinson Disease. Even though there is no standard treatment for the disease, because it's progressive and has no cure, there are some technologies that help the patients with their daily routine. Early symptoms of Parkinson's disease are usually mild and generally occur gradually. As the disease progresses, it begins to interrupt daily activities The most common symptoms are tremors, especially in the arm. In this project, a simulation of a hand tremor will be carried out, and three motors will be used in order to determine which one neglects the vibration of the hand; the Coin-type, the Bar-type and the Uxcell motor. The Uxcell motor has less angular frequency, 25 rads/sec, and was able to reduce, in a more efficient way, the vibration of the hand.*

INTRODUCTION

Parkinson Disease is a degenerative disorder of the central nervous system that affects the motor system. Mostly, it's diagnosed after the age of 60. This affects people's daily routine, like walking or eating.

Today some treatments for the Parkinson Disease (PD) exist. Even though there is no standard treatment for the disease, because it's progressive and has no cure, there are some technologies that help the patients with their life's routine.

The purpose of this project is to simulate a PD hand tremor and to test different motors to see which one is capable of reducing its vibration. Three types of motor were tested for this project; the Coin-type, Bar-type and the Uxcell motor. Individual tests were performed to see how much they vibrate on their own. The acceleration was also calculated.

There are limitations to this work. This is because it will be simulated and, therefore, it will not be very accurate as it would with a PD patient. Obtaining the permits to perform tests on patients was a limitation and that is the reason it was decided to simulate it. However, the results of this project could lead to the creation of new devices that could help PD patients with their daily routine.

LITERATURE REVIEW

Companies like Google or Gyenno Technologies have picked their interest on finding a better way to help PD patients.

Liftware team joined Google Life Sciences in 2014. A group of scientists and engineers working to develop new technologies that provides assistance for people with hand tremors and limited hand and arm mobility. They created an interchangeable spoon and fork attachment and micro sensors that counter attack the hand tremors by moving in the opposite direction [1]. There are two different products. First, there is Liftware Steady. It's an electronic stabilizing handle and a selection of attachments that include a soup spoon, everyday spoon, and fork. The stabilizing handle contains sensors that detect hand motion and a small onboard computer that distinguishes an unwanted tremor from the intended movement of the hand. To stabilize the utensil, the computer directs two motors in the handle to move the utensil attachment in the opposite direction of any detected tremor. Battery lasts for at least one hour [1].

The second product is Liftware Level. Liftware Level is designed to help people with limited hand and arm mobility, (which may be related to cerebral palsy, spinal cord injury, Huntington's disease, or post-stroke deficits) eat more easily. Liftware Level uses electronic motion-stabilizing technology to keep your utensil level, regardless of how your hand or arm twists, bends, or moves. Battery lasts for one hour [1].

There's also Gyenno Technology. Gyenno Technologies is a high-new-tech company that aims at neurology. They created a more accurate spoon for a better stabilization. It provides a 360 degree of stabilization, compen-

Table 1 - Course Information

sating 85% of the unwanted hand tremor using high-speed servo control system for a fast accurate stabilization. It switches on and off automatically, and automatically turns to sleep mode when is not in use to save power. Its maximum time of use is 180 minutes (3 hours), enough to run three meals a day, and has a notification light to show the battery status [1].

There is also a technology that helps the PD patient to walk smoothly and steadily. Since PD is a neurological thief that robs people of the control over their own bodies, a research group from the University of Delaware created the PDShoe. The PDShoe is an ordinary beach shoe equipped with force sensors and a simple vibration system. It was developed by the research group of Sunil Agrawal, UD professor of mechanical engineering, with support from the U.S.-India Science and Technology Endowment Fund. Agrawal and Ingrid Pretzer-Aboff, assistant professor of nursing, are collaborating with the neurology and physiotherapy faculties at the All India Institute of Medical Sciences (AIIMS) in New Delhi to evaluate and pilot test the PDShoe, which aims to help subjects with PD to walk more steadily and smoothly. Kyle Winfree, a doctoral student in UD's Biomechanics and Movement Science program, explains that the vibration in the robotic shoe is synchronized to the heel strike and toe-off of the person wearing it, so it delivers a vibration every time the foot strikes the ground [2].

Thus far, the team has done three pilot studies, two at AIIMS and one at UD, with a total of 27 subjects. The researchers evaluated two measures: stride length and stance-to-swing ratio (basically a measure of how long it takes the person to complete a step from start to finish). Subjects included patients with PD, and healthy individuals who served as a control group [2].

A team of students from Imperial College London creates their tremor-reducing glove called GyroGlove. The glove uses gyroscopes. They take discs and spin them faster than a jet engine, coupling them to the hand. The spinning discs resist movement, with an overall effect that feels like moving your hand through viscous treacle. It thus allows for movement, whilst stabilizing tremors. The GyroGlove uses intelligent electronics to track the progress of the disease, displaying the information on a smartphone [3].

In people with Parkinson's disease, the cells that produce dopamine start to die. Dopamine is a chemical that helps you move normally. Symptoms may include: loss of balance, tremors, slowing of movements etc.

Parkinson's disease is classified in stages, ranging from I to V. Stage V is the most advanced and debilitating stage. Age is another factor in the diagnosis and outlook for Parkinson's disease [4].

Parkinson's disease can't be cured, but medications may markedly improve your symptoms. In occasional cases, your doctor may suggest surgery to regulate certain regions of your brain and improve your symptoms. Sometimes Parkinson's disease can make it harder and less safe to do basic activities like bathing, dressing, eating, sleeping and even walking.

Most people will be diagnosed after the age of 60, but there are others like Emma Lawton that was diagnosed with Parkinson's at age 29. The symptoms caused her involuntary tremors which means Emma was unable to even write her own name. As a graphic designer, this caused her a lot of trouble [4].

The purpose of this project is to simulate a vibration disturbance and see if it can be controlled using vibration motors. This information could later be used to design an arm tremors isolator for PD (Parkinson Disease) that could, in a more efficient way, help with these symptoms.

Early symptoms of Parkinson's disease are usually mild and generally occur gradually. As the disease progresses, it begins to interrupt daily activities [5]. Common Symptoms are: Muscle rigidity, tremor, Bradykinesia, among others.

Bradykinesia

Bradykinesia is the slowing down of movement and the gradual loss of spontaneous activity. It is caused by the brain's slowness in transmitting the necessary instructions to the appropriate parts of the body. This symptom is especially stressful for people with Parkinson's, given that it is unpredictable and can be quickly disabling. One moment a person is moving easily; the next, they need help moving at all. This makes accomplishing simple tasks and participating in daily routines extremely difficult. Bradykinesia affecting the facial muscles may cause the mask-like appearance seen in Parkinson's. [5]

Muscle Rigidity

Occurs when a muscle or groups of muscles stay contracted or partly contracted for an extended period. The brain continues to send nerve signals telling the muscle to contract even when the muscle is no longer needed for movement. This can sometimes last for several hours or days. The longer your muscle remains contracted, the more pain you'll feel [6].

Tremor

Tremor (shaking) begins in the hands and arms, although it can also occur in the jaw or foot. Tremors typically involves the rubbing of the thumb against the forefinger, and is more apparent when the hand is at rest, or you are under stress. In the early stages of the disease it usually only affects one side of the body or one limb. As Parkinson's progresses, tremor may affect other parts of the body. Not every person with Parkinson's disease has tremor. It can also be a symptom of other conditions.

Different Types of Tremors

Essential Tremor, is a trembling of the hands, head, legs, body or voice and is most noticeable when you are moving. This is a common type of tremor and as such, often mistaken for Parkinson's.

Dystonic tremor, can occur because of dystonia (a range of movement disorders that cause muscle spasms and contractions).

People with Parkinson's don't have enough of a chemical called dopamine. This is because some nerve cells in their brain that produce dopamine have died [7].

Other symptoms of PD are: loss of balance, head shaking, loss of motor skills depression, confusion, foward or backward lean that can cause falls and voice and speech changes (voice will become softer with poor enunciation).

Hand Muscles

The muscles that are affected in the hand are the Muscles of the Posterior Forearm. Those muscles are: Brachioradialis, Extensor Carpi Radialis Longus and Brevis, Extensor Digitorum, Extensor Digiti Minimi, Extensor Carpi Ulnaris and Anconeus [8]. Figure 1 shows the muscles mentioned.

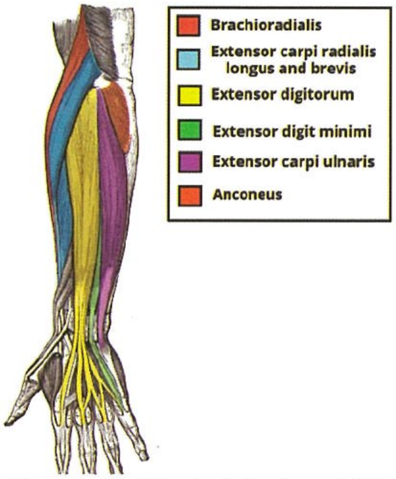

Figure 1 - The Muscles in the Superficial Layer of the Posterior Forearm

Natural frequency of the hand muscle has also been conducted using Finite Element analysis [9]. This model serves as an example of how the vibration amplitude and frequency are going to be calculated in this project [9]. Figure 2 shows the setup for the Natural Frequency reading.

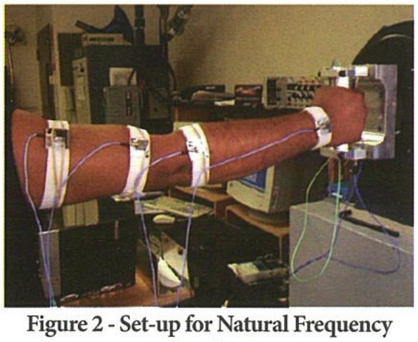

Figure 2 - Set-up for Natural Frequency Reading

METHODOLOGY

It will be explained here which materials and process will be used to analyze how much the vibration frequency of three different motors can affect the PD simulation frequency.

Materials

- **LabView**: It will be used to acquire the motor's vibration frequencies. It's an engineering software system for applications that require test, measurement, and control with rapid access to hardware and data insights.
- **Coin-type motor**: Figure 3 shows how the motor looks like. This motor was used in a project made by Microsoft inventor to ease the tremor of her friend [10]. This is the main reason why this motor was chosen. This motor proves to be efficient in reducing PD tremor in the wrist.

It's comprised of a weight, a ring magnet, rotor with commutation points attached in the front and coils assembled on the back, and power supplied brushes attached to the ring magnet as shown in Figure 4 [11].

Figure 3 - Coin-Type Motor

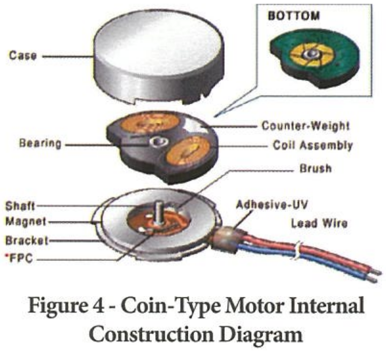

Figure 4 - Coin-Type Motor Internal Construction Diagram

This motor has limited values for the voltage, current and speed. Table 1 shows (next page) the construction form for this motor.

- **Bar-type motor**: This vibrating motor, shown in Figure 5, is essentially a motor that is impro-

Table 1
Coin-Type Construction Form

Rated Voltage	3.0V DC
Rated Current	60mA
Rated Speed	13000+/-3000 rpm/min
Starting Voltage	2.0V DC
Operating Voltage	2.3 to 3.6V DC

perly balanced. In other words, there is an off-centered weight attached to the motor's rotational shaft that produces a centrifugal force while rotating. This unbalanced force displaces the motor. Its high speed displacement makes the motor to wobble, which is known as the "vibrating". Its internal construction is shown in Figure 6 [11].

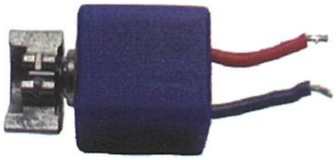
Figure 5 - Bar-Type Motor

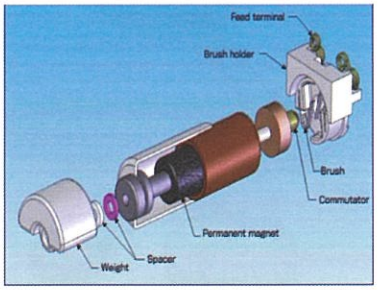

Figure 6 - Bar-Type Motor Internal Construction Diagram

Same has the Coin-type motor, this motor also has limited values for the voltage, current and speed. Table 2 shows the construction form for this motor.

Table 2
Bar-Type Construction Form

Rated Voltage	3.0V DC
Rated Current	90mA
Rated Speed	8500+/-3000 rpm/min
Starting Voltage	2.4 V DC
Operating Voltage	2.4 to 3.6V DC


Figure 7 - Uxcell Vibration Motor

Table 3 shows the values for the rated voltage and speed for this motor

Table 3
Uxcell Vibration Motor Construction Form

Rated Voltage	12.0V DC
Rated Speed	5700 rpm/min

- **Signal Conditioner**: Converts one type of electrical or mechanical signal (input-signal) into another (output-signal). The purpose is to amplify and convert this signal into an easy to read and compatible form for data-acquisition or machine-control. Figure 8 shows the Signal Conditioner that was used.

Figure 8 - Signal Conditioner

- **Accelerometer**: Accelerometers are devices that measure acceleration, which is the rate of change of velocity of an object. They measure in meters per second squared (m/s2) or in G-forces (g). Accelerometers are useful for sensing vibrations in systems or for orientation applications. Figure 9 shows the used Accelerometer.


Fgure 9 - Accelerometer

Procedure

Using the materials mentioned above, the measurements of the frequencies of the three types of motors will be taken. Also, a PD simulation using a motor similar in weight to an Uxcell motor without a weight that is already attached to it, but, one that has no weight but a heavier weight will be attached in order to have a big vibration amplitude.

The purpose is to compare how much the vibrations of these motors will reduce amplitude of the motor with a heavier weight. Since when a tremor occurs in the hand it's also, for obvious reason, moving weight. That's the reason for the extra weight.

RESULTS AND DISCUSSION

In this section the observations of the project will be discussed.

LabView

Figure 10 shows the Block Diagram code for LabView used in this project.

PD Simulation

This section shows the vibration reading using the accelerometer for the PD simulation. Figure 11 shows the setup for the PD hand tremor simulation.
Using a doll hand, the motor with the extra weight was attached, as shown.

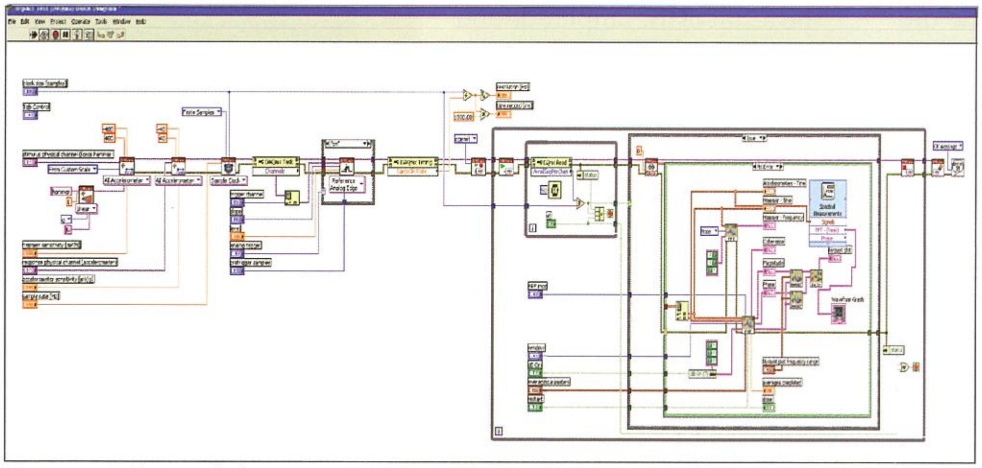

Figura 10 - LabView Block Diagram

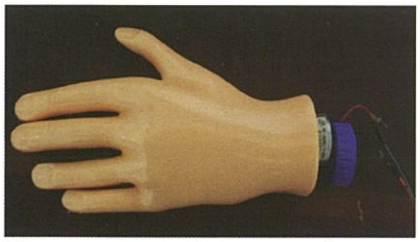

Figure 11 - PD Hand Tremor simulation

Figure 12 shows that the vibration goes from -1.2mV to 1.45mV aproximately, making its amplitude 1.325mV with a vertical shift of 0.125mV. Because of the weight that was placed in the motor, little disturbance appears in the sine wave for a better simulation. The angular frequency, Figure 13, is approximately 42 rad/s which make its frequency 6.68 Hz.

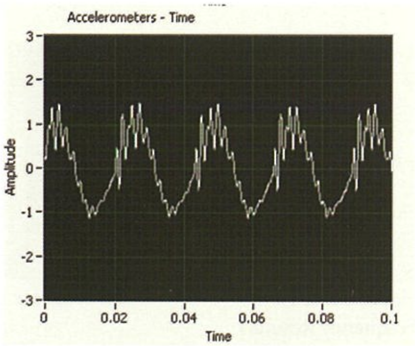

Figure 12 - PD Vibration Reading

Vibration Motors Simulation

This section shows the vibration and frequency readings for the motors used in this project.

First, is the setup for the Bar-type motor as shown in Figure 14.

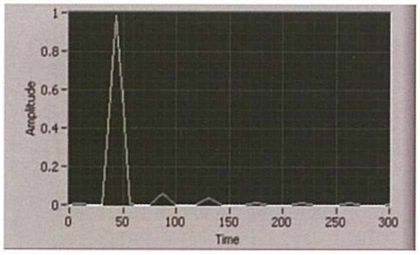

Figure 13 - PD Angular Frequency Reading

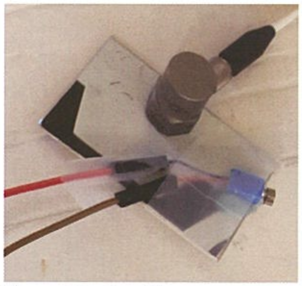

Figure 14 - Bar-Type setup

Figures 15 and 16, shows that the vibration goes from -2.45mV to 2.25mV making its amplitude 2.35mV with a vertical shift of 0.1mV approximately and approximately 200 rad/s for the angular frequency making its frequency 31.83 Hz.

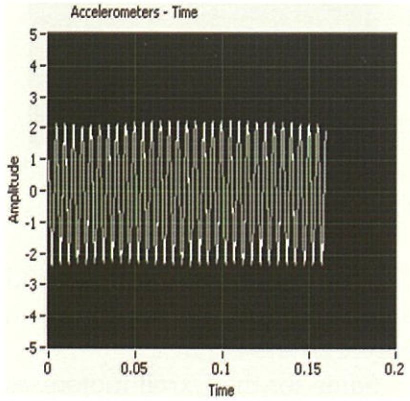

Figure 15 - Bar-Type Reading

Secondly, the Coin-type motor setup as shown in Figure 17.

For the coin-type, the vibration goes from -1mV to 1.25mV approximately, shown in Figure 18. Its amplitude is 1.125 mV with a vertical shift of 0.125 mV. Figure 19 shows a 162 rad/s for the approximate angular frequency and 25.78 Hz.

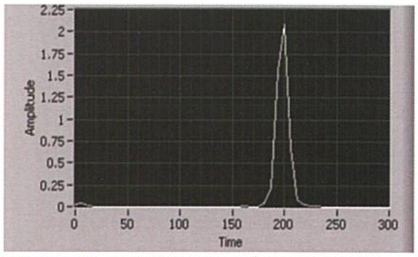

Figure 16 - Bar-Type Angular Frequency Reading

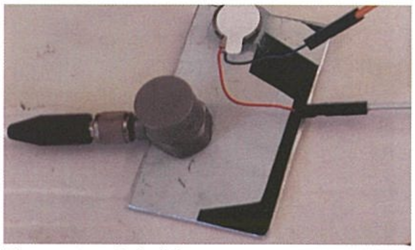

Figure 17 - Coin-Type setup

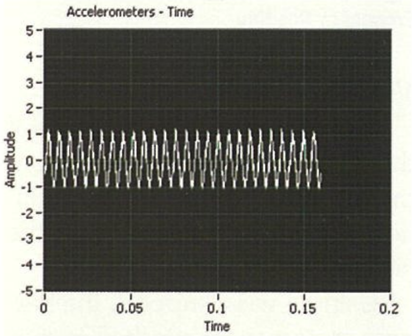

Figure 18 - Coin-Type Reading

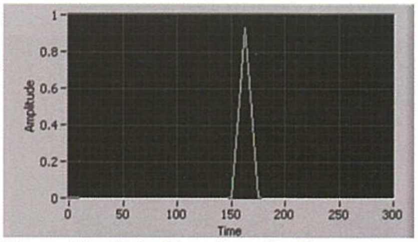

Figure 19 - Coin-Type Angular FrequencyReading

In terms of amplitude, the difference between these two motors is approximately 1.

The third motor is the Uxcell vibration motor. This motor produces a much smoother graph because of its low frequency. Figure 20 shows that its vibration goes from -0.8mV to 0.8mV making its amplitude 0.8 mV approximately with 0 mV vertical shift. Angular frequency, Figure 21, is approximately 25 rad/s which is 3.98 Hz.

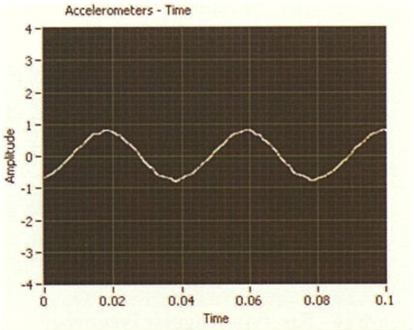

Figure 20 - Uxcell Vibration Reading

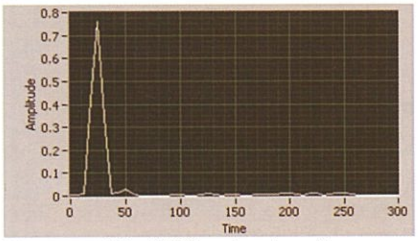

Figure 21 - Uxcell Vibration Angular Frequency Reading

Vibration Motors Tests

This section shows the results of the motors when they tried to control the vibration of the PD simulation. This will be discussed in the next section.

Using a wrist support, the Bar-type motors were attached to it as shown in Figure 22.

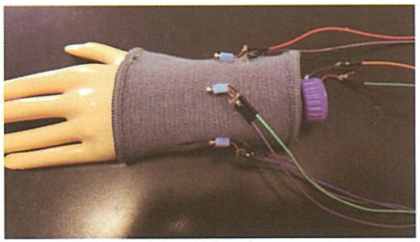

Figure 22 - Bar-Type Test Setup

The result of the amplitude and angular frequencies are shown in Figure 23 and Figure 24.

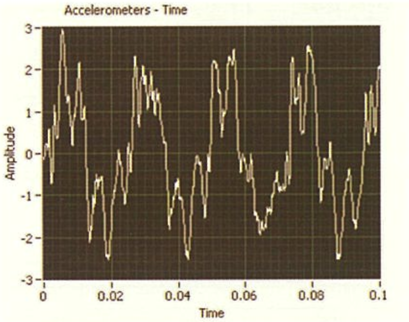

Figure 23 - Bar-Type Motor Test

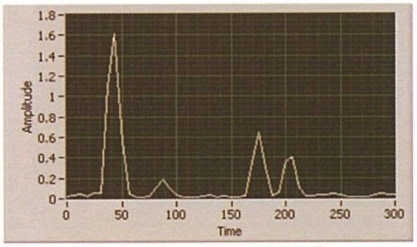

Figure 24 - Bar-Type Motor Angular Frequency Results

It was the same for the Coin-type motors as shown in Figure 25.

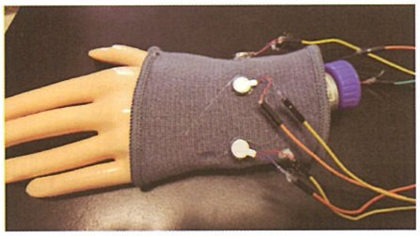

Figure 25 - Coin-Type Test Setup

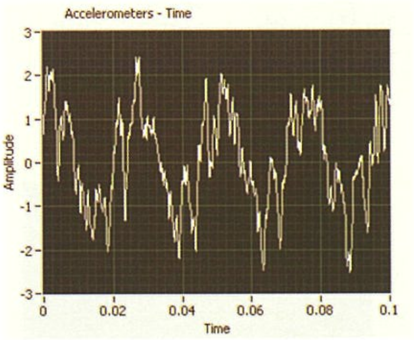

Figure 26 - Coin-Type Motor Test

The result of the amplitude and angular frequencies are shown in Figure 26 and Figure 27.

Same for the Uxcell motors, as shown in Figure 28.

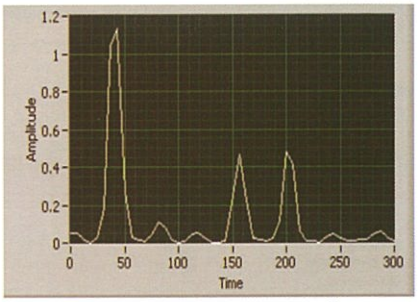

Figure 27 - Coin-Type Motor Angular Frequency Results

The result of the amplitude and angular frequencies are shown in Figure 29 and Figure 30.

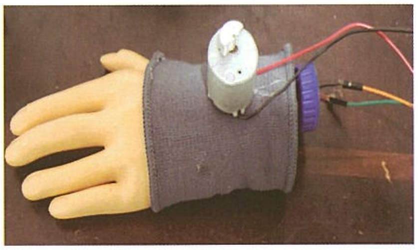

Figure 28 - Uxcell test setup

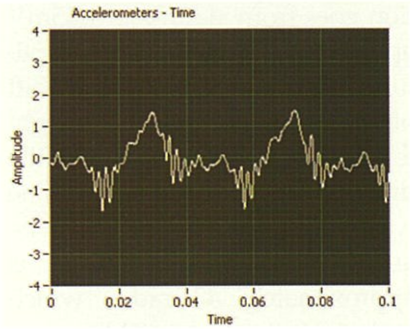

Figure 29 - Uxcell Vibration Motor Test

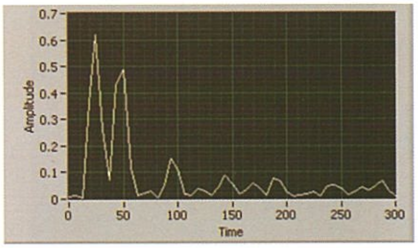

Figure 30 - Uxcell Vibration Motor Angular Frequency Results

Since the first motor, the Bar-type, has an angular frequency of 200 rad/s and a little weight already attached to it, it produces a rough oscillation and a big amplitude in short time. Therefore, it barely goes opposite to the vibration of the PD producing an increase in the amplitude. The Coin-type motor oscillates at an angular frequency of 162 rad/s but does not have a weight attached to it, so the amplitude still increases but not has much as the Bar-type motor. Same as the previous motor, it barely goes opposite to the vibration of the PD producing an increase in the amplitude.

The Uxcell vibration motor, even though it has a weight attached to it, produces an angular frequency of 25 rad/s, a small amplitude of 0.8mV, and a smooth sine wave. As it is presented in Figure 22, most of the vibration amplitudes are between -0.6 mV and 0.4 mV making its amplitude 0.5 mV.

The accelerometer has a sensitivity of 10.33mV/m/s2. Therefore, the acceleration for the simulation of the three motors can be calculated using the following equation:

$$a = amplitude \,/\, accelerometer\_sensitivity \quad (1)$$

The acceleration from the Vibration motors and PD simulations are:

PD 0.128 m/s2
Bar-Type motor 0.227 m/s2
Coin-Type motor 0.109 m/s2
Uxcell motor 0.077 m/s2

From the test the Uxcell motor reduces the amplitude more efficiently than the others. The acceleration obtained was 0.048 m/s2. That's 91% of difference.

CONCLUSION

Out of the three motors, the Uxcell motor proved to be more efficient for the task. Since this is only a simulation, it is necessary to conduct a more realistic test to confirm these results. It would be more specific if tests were done on PD patients. Also, it's seems that vibrations alone are not enough and weight must be applied.

FUTURE WORKS

For future works an ANSYS simulation is recommended. ANSYS can perform load analysis indicating where the highest vibration is and could lead to a better performance given the location that needs most of the vibration.

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