Benchmark Device To Mitigate Jaw Tremor Using Gyroscopic Effect

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Abstract. A tremor is a mildly rhythmic muscle contraction and relaxation that predominantly involves involuntary oscillations or twitching movements of one's body parts. Jaw tremor looks more like shivering although with different amplitude and frequency which can vary. Jaw tremors hinder patients' day to day activities and hamper confidence, causing social handicaps. There are only drug-based solutions for jaw tremors to date. Currently, there are some surgical treatments like Deep Brain Stimulation (DBS), but, they have side effects. Our solution - the palliator a wearable, ergonomic device that dampens jaw tremors without producing any side effects on patients. The proposed solution uses two accelerometers to detect and distinguish involuntary tremors from the voluntary jaw motion and then uses the gyroscopic principle to control the involuntary motion, thus resisting the tremors.

Keywords: Jaw tremor, gyroscopic principle, prosthetic jaw gear, involuntary and voluntary jaw motion.

1. Introduction
A tremor is a mildly rhythmic muscle contraction and relaxation that predominantly involves involuntary oscillations or twitching movements of one's body parts. It can affect the arms, legs, trunk, head, vocal folds, face, and legs [1]. Each tremor has its characteristic cause, frequency and amplitude [3]. Tremor is associated with disorders pertaining to those parts of the brain that control muscles in various parts of the body, such as jaws and hands. Sometimes, neurological disorders can produce tremors such as multiple sclerosis, traumatic brain injury, chronic kidney disease and a number of neurodegenerative diseases that damage or destroy parts of the brainstem or the cerebellum.

However, tremor is annoying. Among all tremors jaw tremor mainly is found to cause more nuisance in patients. In some cases, the tremors hinder their day to day activities like speech, eating, sleep, etc. Almost 0.5 to 0.3\% of the world population suffer from jaw tremors. There are only drugs and invasive
surgical treatments to control jaw tremors to date, and there is no product to address the same in the market.

Effects of Jaw Tremor includes Injuries due to teeth ruptures and tongue biting. The voice will get heavily distorted that may cause difficulty in hearing for other people. They may find it challenging to find the right words, which in turn makes the speech a dragged one. Due to the lack of ups and downs in their tone, people may find it monotonous. Sometimes, they might also speak rapidly, which makes it challenging to comprehend. These problems faced by the affected people may leave a permanent dent in their social confidence and self-comfort. Use of drugs consumed to suppress the jaw tremor and thereby its side effects like Redness, bruises, infections, pain, dizziness, mild difficulty in swallowing, respiratory conditions such as cold or flu, pain, nausea, headache and muscle weakness may occur as these medications are used to relax the muscles. Double vision, eye irritation, drooping or swollen eyelid, reduced blinking and increased sensitivity to light may also occur. Treatments like Deep Brain Stimulation (DBS) [1] have many side effects like seizure, infection, headache, confusion, and stroke.

As mentioned earlier, jaw tremors can also be caused due to various neurological disorders such as essential tremor [5], Parkinson's disease [3], hereditary Geniospasm, Dystonia, Branchial Myoclonus, Whipple's disease, and in everyday situations such as shivering and subclinical physiological jaw tremor as well. Usually, jaw tremor is accompanied by other typically occurring tremors (in head, hand, leg). The frequency of jaw tremor is in the range of 5-12 Hz [4].

2. Solution

2.1. Primary Objective
The main objective is to design an ergonomic wearable device, as shown in Figure 1 that achieves the following major functions:

- Resists the jaw tremors and augment social comfort in people having jaw tremors.
- Aids the people in speaking.
- Reduces injuries from teeth rupture and tongue biting.

![Figure 1. Computer-Aided Design model.](image)

2.2. Working Principle
The proposed solution uses two accelerometers to detect and distinguish involuntary tremors from the voluntary jaw motion and then uses the gyroscopic principle to control the involuntary motion, thus resisting the tremors.
2.3. Setup and component description

A prosthetic jaw gear is stuck to the lower jawline using Nylon reinforced silicon. The jaw gear houses the two servo motors, an accelerometer and the gyroscope. The battery, microcontroller and electronic speed control are mounted onto the headband.

| Components    | Description                                                                 |
|---------------|-----------------------------------------------------------------------------|
| Gyroscope     | Circular thin mild steel ring connected the motor, where one end is         |
|               | connected to the housing and the other end is connected to 2 strings.       |
| Jaw Gear      | Structure over the silicone tape to which gyroscope, 2micro servo,          |
|               | accelerometers are mounted.                                                 |
| Micro servo   | Attached to the frame which is utilized to control the winding and unwinding|
|               | of strings                                                                  |
| Silicone tape | Contains adhesive substance to affix it to the mandibular part              |
| Battery       | Placed inside the headband for powering the microcontroller, gyroscope,     |
|               | accelerometers and micro servos                                             |
| Microcontroller| Positioned inside the headband used to control actuators                     |
| Electronic Speed Controller | Guides the RPM of gyroscope                                       |

2.4. Working

The motion of the jaw is sensed using an accelerometer that is placed below the chin. Another accelerometer is placed at the head so that the system eliminates other body motions and transmits the signals to the microcontroller. The microcontroller receives its input from the accelerometer and distinguishes the involuntary tremor from the voluntary motion of the jaw. When the involuntary signal is detected, the microcontroller will actuate the two micro servo motors through Electronics Speed Controller. This leads to the winding of the string in one of the servos and simultaneously unwinding of the string in the other servo at the same rate to have the strings taut. The string is connected to one end of the axis of gyroscope, which rotates below the chin with the axis being perpendicular to the chin. As the string becomes taut, it pulls the axis of the gyro element, thereby shifting the angular momentum vector of the gyro element. As the gyroscope tries to retain the angular momentum, it produces a torque opposite to the torque produced by the involuntary jaw motion and hence dampening the jaw tremor.
2.5. Basic Algorithm

Initially, a dataset is obtained for a person with jaw tremor using an accelerometer. With the help of this dataset, a linear regression model is employed in which frequency and amplitude of jaw movement are the independent variables and the "Presence of Tremor" being the dependent variable. Linear regression is used here for each person separately because the characteristic frequency and amplitude of jaw tremor for each person varies. Now, with the help of this approach, we would be able to have a reasonably clear distinction between involuntary and voluntary jaw motion. With the help of this, the microcontroller will be able to detect when there is a tremor and actuate the servo motor to produce the counter-torque.
3. Conclusions

From the speech acceleration-time graph (Figure 2), it is observed that in speech, the amplitude of acceleration is lesser, which implies that the muscles controlling jaw movement controls the action of the jaw smoothly. Speech tremor has higher acceleration which implies the amplitude of oscillation is larger, resulting in jaw tremor. Jaw closing force was transduced while subjects maintained a biting force of 9.8 N. This is excellently correlated from our experimental results and met by the gyroscope along the direction of displacement of the lower jaw.

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