Development of Measurement Device and Classification for Tremor Patients Behaviour

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Abstract: - This study is intended to assist neurologist in measuring and identifying the level and range of tremor in some patients who suffer neurological diseases. Prior to quantifying, a suitable measurement device was designed and fabricated. Two laser displacement sensors are used to quantify tremor behavior in X and Y directions. In this paper, two types of tremor condition which are postural and rest tremor were investigated and discussed. The appropriate programming is used to analyze, classify and show range and type of the disease.

Key-Words: - Postural Tremor, Rest Tremor

1 Introduction
Movement disorder diseases can disturb patient’s life. One of the most common is Parkinson. Patients will face problems in picking up and holding objects because of tremor or vibration of hands which is the most obvious and important symptoms of tremor diseases [1]. Tremor is an abnormal repetitive shaking movement of the body which is unintentional and rhythmic. Muscle shaking may involve any limbs (even the head or voice), but it is often obvious in the hands [2]. Elimination or at least reduction of this tremor is the final goal of any research in this area. In order to achieve this, relevant data of disease and type of disease should be obtained. The main features of each tremor are frequency and amplitude. Tremor frequency is mostly depended on the pathophysiological mechanism and is fairly stable over time [3]. There are three main positions to measure the hand tremor (include: resting, postural and action position). Each disease is recognizable at specific position [4]. This paper addresses on resting and postural conditions and classify them to five ranges. The three main approaches to measure the hand tremor include: 1- acceleration transducer 2-velocity transducer 3-displacement transducer. This paper is focused on displacement transducers, utilizing laser displacement sensors on two main axes of tremor (X, Y).

This system includes two main parts 1-harware 2-software, and outputs of hardware are inputs of software. This study is intended to assist neurologist in measuring and identifying the level and range of tremor in patients who suffer neurological diseases (this study covers only the hand tremor). The proposed classification provides for a fast identification of the type and level of the disease.

2 Device Designing
As shown in Figure 1, an appropriate device is designed to measure the hand tremor and obtain the data. Coherence device is switchable between the two main conditions (resting, postural). The holder part (Figure 1) is adjustable to change the position of measurement. Laser displacement sensors are installed on the hollow cylinder. One is installed along X axis and the other is along Y axis. A hand part (Figure 2) is used to provide a suitable reflection beam from the sensors. The light spot of this instrument should be approximately adjusted to the center of the target that is attached on the basic plate to stay in range position. In postural condition, patient extends the forearm on the supporter after inserting the hand into the cylinder, while in resting condition, patient stands next to the table and places the hand through the cylinder. All data are collected using coherence data acquisition card to transfer to software. Figure 3 shows the hardware and software configuration of the experimental rig.
Fig. 1: Measurement device in a) Postural condition b) Resting condition

Fig. 2: Hand part

Fig. 3: Hardware and software configuration of the experimental rig
3 Data Computing

3.1 Superposition

For the purpose of superposition of vertical wave (along X axis) and horizontal wave (along Y axis), it is required to calculate the peak frequency for each direction and then apply the formula to obtain the frequency of final orbital motion on the surface. For the purpose of calculating the frequency of each signal, spectral measurements is used where the input is filtered signal and the output is frequency spectrum. Frequency peak is obtained from this output. Output of frequency estimated is a number which states the frequency peak of tremor. The procedure was then repeated for the other direction. The two different numbers serve as input to the equation.

The final step of obtaining orbital motion frequency includes the superposition equation (1) which shows the frequency of orbital motion. This number is input of the classification.

\[ F_{\text{orbital}} = \sqrt{F_x^2 + F_y^2} \]  

(1)

3.2 Classification

For the purpose of classification of hand tremor and recognizing of disease type, it is required to define some ranges and intervals (Table 1). Each type of hand tremor disease occurs in one specific range (frequency interval) and is more obvious in one specific condition (resting or postural).

Table 1: Classification of tremor diseases according to frequency ranges and conditions.

<table>
<thead>
<tr>
<th>Tremor type</th>
<th>Condition</th>
<th>Frequency range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holmes</td>
<td>resting</td>
<td>2-4 Hz</td>
</tr>
<tr>
<td>Parkinson</td>
<td>resting</td>
<td>4-10 Hz</td>
</tr>
<tr>
<td>Neuropathic</td>
<td>postural</td>
<td>4-6 Hz</td>
</tr>
<tr>
<td>Low Essential</td>
<td>postural</td>
<td>6-10 Hz</td>
</tr>
<tr>
<td>High Essential</td>
<td>postural</td>
<td>10-12 Hz</td>
</tr>
</tbody>
</table>

Hardware part supports both conditions. To match the software part with both conditions, a relay is used which operates as a key to switch between the resting and postural condition. These switches are observable on the control panel and the user is able to turn on/off for each condition. If resting condition is on, the hardware part is in the resting position and postural switch must be off.

This program is using the “while” loop and according to the design method, the program is active while recognizing the hand tremor disease. As shown in Figure 4, after stoppage of program, all results (include: displacement diagram along X axis, displacement diagram along Y axis, frequency graph along X axis, frequency diagram along Y axis, peak frequency along X axis, peak frequency along Y axis, peak frequency on XY, patient’s disease) are provided on control panel. There are also two switches on the control panel [Figure 4] for the user to choose the condition before measurement by turning on/off these keys.

4 Results and Discussions

For the purpose of comprehension and testing the program performance, simulated signals are entered in program which should be received from the device. All of the parameters of sample signals are known and easily adjustable. As shown in Figure 4, condition is assumed as “resting” and recognized disease is Parkinson. Frequency of sample sinusoidal signal along X axis is defined 3 Hz whose signal amplitude is 0.5 mm without any phase angle.

Displacement diagram along X axis is also shown. The frequency graphs are extracted from displacement graph and its result is shown as linear graph. As explained in previously, peak frequency is critical in each direction. The peak frequency in the X direction is correctly identified in comparison with input signal. Also shown, 9 Hz frequency is defined for sinusoidal signal along Y axis and its amplitude is 1mm, without any phase angle.
5 Conclusions
To measure the hand tremor, this study uses two displacement transducers; both of them are laser displacement sensors. The major parameter is amplitude of displacement of hand tremor’s oscillation in this project that has been measured and recorded in the time and frequency domain. And our classification is according to frequency range. This study focuses on measurement of tremor hand at both conditions which include resting and postural condition in two axes (X, Y) because the tremor amplitude is most significant at these axes. There are two important conditions for measuring the hand tremor (resting and postural) because some of diseases appear only in single condition. This system is able to cover two conditions with changing of one part of that. Considered device experimentally is fabricated and is tested with human hand.

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References: