CHAPTER 6

SENSORY NERVE CONDUCTION SYSTEM FOR MEASUREMENT OF NERVE VELOCITY ACROSS THE CARPAL TUNNEL

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6.0 INTRODUCTION

Carpal Tunnel Syndrome (CTS) is the basic fringe nerve issue that happens when the middle nerve keeps running from the lower arm into the palm of the hand, progresses toward becoming crushed or squeezed at the wrist and it has impressive work and medicinal services costs. There is dispute as to whether occupational factors increase the risk of occurrence of CTS, a disabling condition with a self-reported prevalence of 1.55% and direct medical costs of more than one billion dollars each year in United States adults [1]-[2]. There are numerous electrodiagnostic techniques have been produced to aid the conclusion of CTS, the most common nerve entrapment syndrome [3]-[4]. However, there is no consensus as to which technique is the most sensitive or specific [5]-[6]. The conclusion of CTS can be made certainly in patients who present with the trademark history, physical examination discoveries, and electro-analytic irregularities yet certainty decreases as the introduction goes amiss from these trademark discoveries.
6.1 OVERVIEW OF CARPAL TUNNEL SYNDROME

Carpal tunnel syndrome (CTS) is a clinical disorder resulting from compression of the median nerve at the wrist [7]- [8]. The syndrome is common with an estimated population life-time cumulative incidence rate of 8% and it can be associated with substantial disability [9]- [10]. A typical issue in clinical nervous system science is the differential determination of the reason for shivering and deadness of the fingers which might be related with shortcoming of the little muscles of the hand. There is general acknowledgment that disorder may result from pressure of nerve roots or peripheral nerves providing the hand or of the veins providing the influenced nerves and the pressure may happen at different destinations in spine.

The indications of this disorder generally feeling numb or shivering in thumb, wrist and center finger that goes back and forth additionally distress in wrist and the palm. It can feel the vibe of electric stun and shock when lift something. The conceivable reason for the disorders are feel swelling at the floor ligaments, misalignment of carpal bones and direct pressure of the passage. Alternate causes can be from vibration, cool temperature and from the old wounds. The CTS can be group at the three phases. At the primary stage or gentle side starts with the numbness and awkwardness when grasp question, torment reach out to elbow and issue with the fine fingers minute. The second stage or moderate indications can be seen from the troublesome holding little question like securing, getting dressed or conversing with the telephone. At the last stages or serious manifestations may cause the loss of muscle capacity and consistent deadness. Some of the time at this stage, the careful administration likewise cannot resolve this issue.
Nerve Conduction Velocity (NCV) is the speed at which electrochemical drive that spreads down a neural pathway. The conduction of speeds is influenced by a wide cluster of factors including sex, age and different medicinal conditions. Studies take into consideration superior judgments of different neuropathies. For the most part conduction speed is explicit to every person. Nerve motivations are greatly ease back contrasted with the speed of electrical drive however quick contrasted with the speed of blood stream.

NCV can be altered by gender, age and more pertinently, skin temperature [12]. Other known cause like descending pathway of the central nervous system such as endorphins is also trivial [11]-[16]. Evaluation of counter irritant role is difficult to directly evaluate but if the cryotherapy can reduce pain, the independent of any effect on NCV then after the processes may be more important. In the NCV test, the nerve is electrically stimulated by one electrode while the others electrodes will detect the electrical impulse from the first electrode.
NCV test mostly done with surface electrodes just like those used for electrocardiogram (ECG).

6.3 DEVICE DESIGN

The block diagram of this device is shown in Figure 6.2 below.

![Block diagram of the device](image)

In this project, the input is obtained from mini electric shocker to activate the electric pulse. A two point electromyography (EMG) sensor electrode will be attached to the hand of subject or patient. Based on the EMG signal obtained from the sensor, this signal will be amplified further before transmitted to Arduino Uno. Arduino will do the analog-to-digital (ADC) conversion of amplified signal to the digital number to display the NCV result on the LCD display. The time measurement will be performed by using equation (1).

\[
\text{Time (ms)} = 2\text{nd peak signal} - 1\text{st peak signal} \tag{1}
\]
Meanwhile, the distance will be calculated from the difference between positions of two MyoWare electrodes. To obtain the NCV measurement, the velocity formula is given as equation (2).

\[
NCV(\text{ms}^{-1}) = \frac{\text{Distance of recording and stimulation electrodes (m)}}{\text{Latency (s)}}
\]

(2)

Figure 6.3 shows the final device prototype inclusive of MyoWare sensor, surface electrodes, LCD display and hard chassis for placement of Arduino Uno and battery.

![Device Prototype](image)

Figure 6.3: Device Prototype

### 6.4 PROJECT TESTING

The device was tested on 5 volunteers (3 healthy, 2 with symptoms) upon signing an ethical approval letter. The measurement was carried out using experimental procedures which have been regulated in the laboratory and was compared with waveform obtained from Arduino IDE serial plotter. Figure 6.4 shows the experimental procedures and how the sensor was placed.
Figure 6.4: MyoWare sensor and placement on subject’s hand

Figure 6.5 shows an example of Arduino IDE serial plotter output in terms of EMG signals obtained from the subjects.

![EMG Signal Output](image)

Figure 6.5: The EMG signal output from Arduino IDE serial plotter

The serial plotter output was used for comparison purpose. Therefore, the validity of the NCV measurement output can be verified. Table 6.1 below shows the average latency information obtained from five different subjects.
Table 6.1: Latency measurement from Arduino IDE serial plotter

<table>
<thead>
<tr>
<th>Volunteer</th>
<th>Average Time taken (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volunteer 1</td>
<td>0.5</td>
</tr>
<tr>
<td>Volunteer 2</td>
<td>0.6</td>
</tr>
<tr>
<td>Volunteer 3</td>
<td>0.4</td>
</tr>
<tr>
<td>Volunteer 4</td>
<td>0.4</td>
</tr>
<tr>
<td>Volunteer 5</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The average latency measured from all five subjects is around 0.48ms. The NCV final value of all data volunteer shown such in Table 6.2:

Table 6.2: NCV measurement from Arduino IDE serial plotter

<table>
<thead>
<tr>
<th>Volunteer</th>
<th>Average NCV (ms⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volunteer 1</td>
<td>60</td>
</tr>
<tr>
<td>Volunteer 2</td>
<td>50</td>
</tr>
<tr>
<td>Volunteer 3</td>
<td>75</td>
</tr>
<tr>
<td>Volunteer 4</td>
<td>75</td>
</tr>
<tr>
<td>Volunteer 5</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 6.3 below shows the comparison data between both methods.

Table 6.3: NCV comparison data

<table>
<thead>
<tr>
<th>Volunteer</th>
<th>Average NCV (ms⁻¹) (device)</th>
<th>Average NCV (ms⁻¹) (Serial plotter)</th>
<th>Percentage of Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volunteer 1</td>
<td>63.4</td>
<td>60</td>
<td>5</td>
</tr>
<tr>
<td>Volunteer 2</td>
<td>52.1</td>
<td>50</td>
<td>4.03</td>
</tr>
<tr>
<td>Volunteer 3</td>
<td>78.2</td>
<td>75</td>
<td>4.09</td>
</tr>
<tr>
<td>Volunteer 4</td>
<td>76.3</td>
<td>75</td>
<td>1.70</td>
</tr>
<tr>
<td>Volunteer 5</td>
<td>61.5</td>
<td>60</td>
<td>2.43</td>
</tr>
</tbody>
</table>
6.5 CONCLUSION

In a nutshell, this is the first attempt to consolidate the signal from MyoWare sensor and Arduino platform for NCV measurement. It can be seen that both results give considerable amounts of errors whereby it can be improved in near future. For healthy volunteers, the average NCV between 60 – 75 ms\(^{-1}\) was recorded as compared to subject’s with symptoms (50 ms\(^{-1}\)).

6.6 REFERENCES


