Development of Diagnosis Evaluation System of Facial Nerve Paralysis Using sEMG

Shogo Okazaki †, Misaki Syoichizono, Hiroki Tamura ‡
Faculty of Engineering, University of Miyazaki, 1-1, Gakuen-kibanadai-nishi, Miyazaki-shi, Japan

Takahiro Nakashima*, Eiji Kato*, Tetsuya Tono*
*Department of Otolaryngology, Head & Neck surgery, Faculty of Medicine, University of Miyazaki, 1-1, Gakuen-kibanadai-nishi, Miyazaki-shi, Japan
E-mail: hc10010@student.miyazaki-u.ac.jp †, htamura@cc.miyazaki-u.ac.jp ‡

Abstract
In Japan, diagnostic of facial nerve paralysis is mainly used the electroneuronography (ENoG) method. Previous our research showed the certain correlation between ENoG and surface-electromyogram (s-EMG) data. Therefore, we developed the evaluation system of facial nerve paralysis using s-EMG. We compared with our developed software and manual by experimental person. Form simulation result, our developed software showed the correlation coefficient ($R^2$) between ENoG is 0.68.

Keywords: Facial Nerve Paralysis, Surface Electromyogram, Electroneuronography, Multiple Regression Analysis

1. Introduction
Although cause of facial nerve paralysis is unclear, the cause is believed that is one of the causes of viral infection. The main treatments are medication and surgical operation when the symptom is serious. Electroneuronography (abbr. ENoG) test is one of facial nerve diagnosis methods currently in using. However, the ENoG test can’t carry out within one week after onset. For quantitatively diagnose, we focused on the surface-electromyogram (abbr. s-EMG) 1. Previous our research, we found that there is a correlation between the ENoG value and features values of the s-EMG. We developed software to extract the features of s-EMG. In this paper, we compared with the results using software and manual results by correlation coefficient $R^2$ of ENoG value and feature values of s-EMG. In addition, we confirmed how much the manual method can be reproduced in the software method.

2. Previous Research
Previous our research, we investigated the relationship between the ENoG value and the feature values obtained from the s-EMG. Fig.1 shows the attachment position of the electrodes. In the experiment, the following two patterns of facial muscle activity performed five times, and the generated s-EMG measured.
- Motion the mouth horizontally (Motion A)
- Motion closing the eyes strongly (Motion B)
We measured 19 times of facial nerve paralysis: 6 subjects measured twice. Fig.2 shows an example of the s-EMG measured, and sampling frequency is 1000Hz. For these s-EMG, we performed each of frequency analysis by Fast-Fourier-Transform (abbr. FFT) and integrated calculation of s-EMG, and the difference between ch1 and ch2 obtained as the feature values. The
reason for taking the difference is that in the Ref.2 a significant difference in the frequency of the s-EMG confirmed on the affected side and the healthy side. As a result, we obtained four kind of feature values. Next, we investigated the relationship between ENoG value and feature values and parameters that strongly influence using Adaptive – Network – Based – Fuzzy – Inference System (abbr. ANFIS, ANFIS is one of fuzzy inference). Based on the results obtained from ANFIS, we prepared the three rules (shown in Table.1). Here, notA is difference between ch1 and ch2 frequency of the motion A, inteA is difference between ch1 and ch2 integrated value of s-EMG of the motion A, and inteB is difference between ch1 and ch2 integrated value of s-EMG of the motion B. We prepared three groups that divided the feature values by three rules. For each of the three groups, multiple regression analysis performed with the feature values as the explanatory variables and the ENoG values as the objective variable. The predicted of ENoG value was calculated from the result of multiple regression analysis, and feature values confirmed the correlation with ENoG values. As a result, R² was 0.79, and a strong correlation was found. This value set as the result of the manual method, and compare results between software and manual method.

<table>
<thead>
<tr>
<th>Rule</th>
<th>freqA [Hz]</th>
<th>inteA [mV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1</td>
<td>freqA ≥ 14</td>
<td>inteA &lt; 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or inteA ≥ 42</td>
</tr>
<tr>
<td>Rule 2</td>
<td>freqA &lt; 15</td>
<td>inteB ≤ 34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or inteB ≥ 42</td>
</tr>
<tr>
<td>Rule 3</td>
<td>freqA ≤ 30</td>
<td>inteB ≥ 30</td>
</tr>
</tbody>
</table>

Table 1. Three rules.

3. Algorithm

We developed software that implements the methods for extracting feature values used in previous our research. Fig.3 shows the flow of processing. This section explains the processing of the developed software.

3.1. Search of Activity Start Position

In this subsection explain the method of searching for the position on the active part of N times. Y(n) (in Fig.3) is the integrated value of absolute value of X(t) for every 100 data. When for 2 seconds from start of s-EMG measurement, motion had set to do nothing. There B (in Fig.3) is threshold, it set a twice of average of integration values for 1 second from measurement start. If Y(n) are greater than threshold B and more than 7 times for 10 data,
activity start position $P(N)$ (in Fig.3) is set the position at initially beyond threshold $B$.

In this procedure performed on the sEMG data of ch1 and ch2 to extract the frequency. Then, difference in frequency of ch1 and ch2 obtained, and took out as a feature value. Since there are two kinds of motion, the feature value obtained by frequency analysis is two.

![Figure 4](image_url)  
**Fig.4.** Result of frequency analysis and moving average of spectrum.

### 3.3. Integrated s-EMG

Integrated values calculated using s-EMG data from $P(N)$ and the number of FFT data. Then, as the frequency case, the difference between the integrated values of ch1 and ch2 obtained, and two feature values obtained. Finally, a total of four feature values of frequency and integrated value extracted and used as parameters for calculating the predicted value of ENoG value.

### 3.4. Execution Screen of Software

Execution screen of developed out software are show Fig.5, Fig.6, and Fig.7. Fig.5 is reading files of s-EMG measurement. Fig.6 shows the results of position of activity part. These positions can also change by manually. Fig.7 shows the result of ENoG predicted value and condition of facial nerve paralysis diagnosed. Method of diagnosis will described later.

### 4. Analysis

In the previous section, we presented the method of calculating the feature values. We divided the obtained feature values according to the rules in Table.1, and multiple regression analysis performed for each divided data groups. After that, we obtain the predicted value of
6. Conclusion

Predicted values using software, the result of $R^2 = 0.68$ was obtained. Although the correlation coefficient decreased as compared with $R^2 = 0.78$ when manual analysis performed in the previous research, we confirmed a strong correlation still observed with the ENoG value. However, there were two results that the ENoG predicted value of serious patients were significantly different from the actual ENoG value. From now on, it is necessary to predict the ENoG value for s-EMG data of newly measured facial nerve palsy patients, and investigate whether the correlation between the feature values of s-EMG used this time and the ENoG value is reproducible. Also, as necessary, we intend to update the coefficients of the regression equation and adjust the rules in Table.1.

![Fig.7. Execution screen to show the results of ENoG predicted value and condition of facial nerve paralysis diagnosed.](image)

EnoG, and we compare the predicted value of EnoG with actual EnoG. Then, medical condition diagnose using predicted value of EnoG. Diagnostic criteria for each symptom are mild if EnoG is 40 or more, moderate if EnoG is greater than 10 and less than 40, and severe if EnoG is 10 or less.

5. Result

![Fig.6. Execution screen to show the results search position of activity parts.](image)

Fig.8 shows vertical axis is for the predicted value of EnoG value, and horizontal axis is for the EnoG value. The Area 1, Area 2, and Area 3 are areas of each of states severe, moderate and mild. From the figure, the correlation coefficient $R^2$ was 0.68. The success rate when diagnosing the condition using the predicted EnoG was 78.95%.

![Fig.8. Correlation between the predicted value calculated from the output feature quantities and the EnoG values.](image)

References


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