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Frontalis Muscle Strength Calculation Based On 3D Image Using Gray Level Co-occurrence Matrix (GLCM) and Confidence Interval

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Abstract

One of the effects of the disorders of nervus VII (n. Facialis) is the damage of facial muscle. The research is needed in order to detect or as the therapies aids on the damage of the VII nerve by measuring the strength of maximum contraction, to help a therapy or detect the damage which caused by the decreasing of the VII nerve function. These measurement is taken from the difference on myofibrin when the contractions, because when the contraction happen, the myofibrin will distend and the difference can be detected as the strength of contraction. From the result of the comparison, EMG with the test result is the shift muscle movement amount of 1.367 up to 4.460. The mean value of rest muscle is in the range of 0.635 with interval at±0.463, on the move muscles the mean value of the muscle moving is in the range of 3,563 with interval at±1,069. This test is linear with the data EMG

Keywords: *muscle strength, 3D imagery, confidence interval*

1. Introduction

In the facial anatomy, there are muscles which function as the facial expression. These muscles are influenced by the Nervus 7 or Nervus Facialis [1]. In the medical science, this muscle known as Mimetic Muscle, this muscle is responsible for expression. The movements of muscles will produce facial expression. Simply, the anatomy of muscle consists of tip muscle which called as Origo and Insersio and the midpoint of muscle or Belli. From that anatomy, the muscle movements can only contraction and the most moving point is belli.

Facial Palsy or paresis shows the weakness of the facial muscle movement. Palsy usually use on the non-function or even missing of the movement. Moebius syndrome is one of the subtypes of facial palsy which involves the weaknesses of muscles which control the facial expression and lateral eye movement side to side. Moebius syndrome may also involve syndrome of extremity. On the muscle structure, when the muscle is contracting, the shape of muscle will be distended. The muscle that distends can be analyzed and observed because the distend process is the proof of the contraction of the muscle, then the magnitude of the contraction can be calculated by the difference between normal muscle and muscle when contraction. When there is damage or there is a condition of abnormal muscle, then the muscle contraction will not be maximized.

Techniques of data retrieval on muscle contraction still use electrodes placed on the muscles to be recording or retrieving data. This research will provide an alternative in data collection using 3D cameras. Raw data from 3D cameras will be processed using Gray Level Co-Occurrence Matrix (GLCM) and confidence interval. From the this calculation, will get the value that will be used as the magnitude of movement of the frontalis muscle.

From the cases above, it is necessary to conduct some research which connecting between muscle contraction and the nerve damage because until today, the detecting of the damage of a nerve is still use EMG (Electro Miyo Graphic). This research is expected to support the data from EMG.

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2. Related Work

2.1. Face Anatomy

Facial Muscle or Mimetic Muscle, is a group of muscle which used to control facial expression [1]. These muscles are innervated by the nervus facialis or nerve VII. The anatomy of muscles generally consist of origo, insersio, and belli. Origo and insersio are the tip of muscle which stick to the bone or the ligaments, while belli is a muscles which contracted. Skeletal muscles fiber is a group of fasciculus (cylindrical muscle cells which bound by connective tissue). A whole fiber muscles is compiled into one by connective tissue which known as epimysium (fascia).

In the structure of skeletal muscle, the structural unit of muscle tissue is muscle fibers. Skeletal muscle fibers are approximately 0.01-0.1 mm in diameter with a length of 1-40 mm. The increasing age could escalate the amount of tissue, especially elastic tissue. Each of nerve fiber is coated by sarcolemma, a thin elastic tissue. The protoplasm of muscle fibers are made of semi viscous fluid which called as the sarcoplasmic. In the muscle fibers immersed functional unit of muscle with a diameter about 0,001 mm which called myofibril.

Under the microscope, myofibrils would look like crossed dark and light band. Dark band (thick filament) is formed by myosin, meanwhile light band (thin filament) is formed by actin, troponin and tropomyosin). The muscles that contraction will pull Z line closer, as illustrated in Figure 1, the first image is a muscle condition before contraction and the second image is the condition of the contracting muscle. There will be a change of Z line when contraction occurs, and it causes a change of muscular shape. When muscles contraction, it will distend.

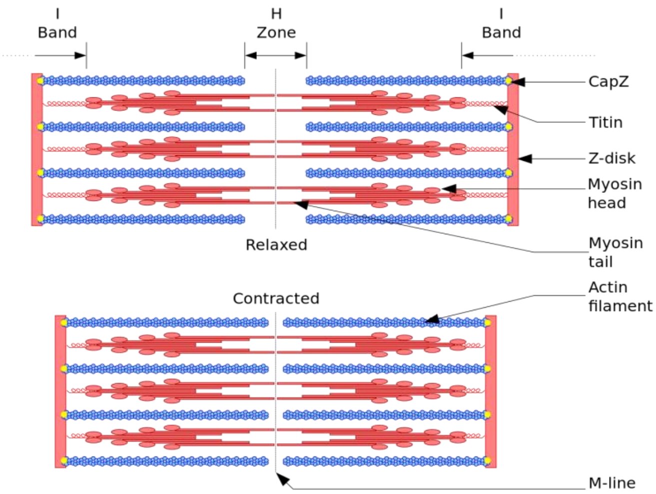

Figure 1. Anatomy of muscle contraction [2]

2.2. Gray Level Co-occurrence Matrix (GLCM)

GLCM method is a method to examine pixel in a image and determine the level of gray [3]. This method is to tabulate the combination of frequency of pixel values which appear on image as well. When analyzing the image which based on the statistical distribution of the intensity of the pixels, it can be performed by extracting the texture features [4].

GLCM is a method to extract the characteristics based on statistical, and the acquisition of characteristics obtained from the pixel value matrix, which have certain values and form an angle pattern [5]. Those pixels make a co-occurrence matrix with a pair of its pixel. Based on the condition that a matrix of pixels will have an iteration value, thus there is a pair of its gray [6]. The condition of the pixel value is denoted as a matrix with a range of two positions (X1, Y1) and (X2, Y2) and Θ tetha defined as the angle between of them. Here are some features that can be calculated using GLCM which consists of seven main features and seven additional features derived from the 7 main features. But in the movement calculation system, it will use the four main features, namely:

Energy is used to calculate the diversity of pixel values. Energy will become a high value when the pixel values are similar to one another. The equation which is used to gain the value of energy is:

$$Energy = \sum_{i,j=0}^{L-1} P^2(i,j,d,\theta) \quad (1)$$

Contrast is used to calculate the gray level of image. Image with smooth texture will create a lower contrast value. Conversely, a sharp texture will generate a high contrast value. The equation to get the contrast value is:

$$Contrast = \sum_{i,j=0}^{L-1} (i-j)^2 . P(i,j,d,\theta) \quad (2)$$

Correlation is used to measure the linear between pixels. The equation used to calculate the correlation is:

$$Correlation = \sum_{i,j=0}^{L-1} \frac{(i-\mu_x)-(j-\mu_y)P(i,j,d,\theta)}{\sigma_x \sigma_y} \quad (3)$$

Entropy is used to measure the complexity/image randomness. Entropy will highly valuable when the images are not in sequence and the equation used to calculate this feature is:

$$Entropy = \sum_{i,j=0}^{L-1} P(i,j,d,\theta). \log P(i,j,d,\theta) \quad (4)$$

2.3. Confidence Interval

In this stage, confidence interval method is used to determine the probe value on a data. If the value of the data is still between the range of probe value then the data is proved to be right, otherwise the value is beyond the range of probe value means that the data is error. The step in forming confidence interval is determine the mean value on each data,

$$\overline{x} = \frac{\sum x}{n} \quad (5)$$

where : $\bar{x}$ =mean
$\sum x$=data values
n=sample size

Mean value is used to determine the average of a data to be processed, in this research, mean will be taken from deviation data of entire normal face length minus contraction face, mean will be calculated from the result of those data deviations, and it will be processed on standard deviation formula.

$$\delta = \sqrt{\frac{\sum (x-\bar{x})^2}{n}} \quad (6)$$

After determine the standard deviation, the next step is determine the level of confidence, and in this research, the level of confidence which is used is 95%. Next is calculate the *margin of error* by using the formula as follow,

$$Z_{a/2} . \frac{\delta}{\sqrt{(n)}} \quad (7)$$

where : $Z_{a/2}$=confidence coefficient
a=level of confidence
σ=standard deviation
n=sample size

Margin of error is used to determine the upper and lower limit of data span. Z table is needed to determine the margin of error and from the table, the upper and lower limit can be determined.

$$\bar{x} \pm Z_{a/2} \cdot \frac{\delta}{\sqrt{(n)}} \quad (8)$$

The result of confidence interval calculation is limit value which is used to determine the upper and lower limit of a data if normal face stands on 0 coordinate, then, the upper limit is between negative of confidence interval value up to confidence interval value.

2.4. Image Adjustment

The technique of image adjustment is used to improve the quality of an image, where the improvement of image is usually subjective like creates particular feature is easier to view by modifying the color or intensity. Processing in form of contrast value improvement will be done in this research. The calculation of contrast value improvement on this research is using formula,

$$f_{0(x,y)} = G.(f_i(x,y) - P) + P \quad (9)$$

3. Results and Analysis

3.1. Analysis

This stage aims for diagrammatic software design so that the desirable model based on needs can be obtained. Also, with this diagram design, the flow of data processing work frame will be seen. The following is scheme of research methodology,

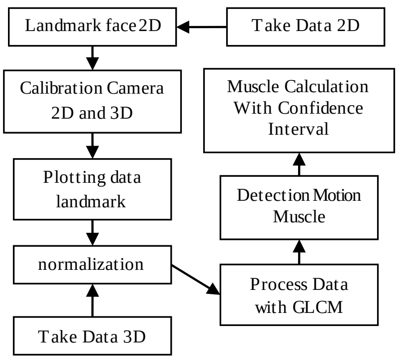

Figure 2. Flow diagram

From the scheme in Figure 2, it is divided into two main parts which are 2D data processing and 3D data processing to produce muscle strength prediction and muscle strength magnitude.

3.1.1. Calibration 2D and 3D Camera

Camera is set of equipment in which it has function to capture and object into picture as the result of projection on lens system. 2-dimension camera is a camera in which the result only contains with array 2D, the array contains color range between 0 up to 225, whereas 3D camera contains array which is different from 2D and the difference is in 3D camera, there is deepness information and its coordinate which makes 3D camera hold more deepness information from capture result.

The differences between 2D and 3D cameras are such as the angle and the resolution of the picture. 2D camera captures picture of 640x480, meanwhile the 3D camera captures picture of 320x240. The compression of 2D picture into 320x240 is necessary before the data can be used because the resolution of 3D picture is half of 2D picture. Besides resolution, the shift point of 2D and 3D is also different. Those differences require calibration process on camera, so the 2D data can be used on 3D data. The calibration can be done using the following formula,

$$(x' , y')=\begin{Bmatrix} x' = \frac{x . x_2}{x_1} \\ y' = \frac{y . y_2}{y_1} \end{Bmatrix} \quad (10)$$

Where :x_1=coordinates (X) on the 2D camera
x_2=coordinates (X) on the 3D camera
y_1=coordinate (Y) on a 2D camera
y_2=coordinate (Y) on a 3D camera

The calibration process on these two cameras will produced a magnitude value based on test points of 2D and 3D cameras. Points on 3D camera with x,y,z coordinates (165,122,305) are same with points on 2D camera with x,y coordinates (190,131). A formula of data calibration on 2D camera into 3D camera such as formula in 3.1 is obtained from these two points.

3.1.2. Data Normalization

The results captured by 3D camera is in the form of raw data and the results of the 3D imaging data still indicates difference on the uneven contour. At this stage, the capturing of 3D face data will conduct. The data is captured using Senz3D camera and Unity Game Engine tool. Data were taken as follows,

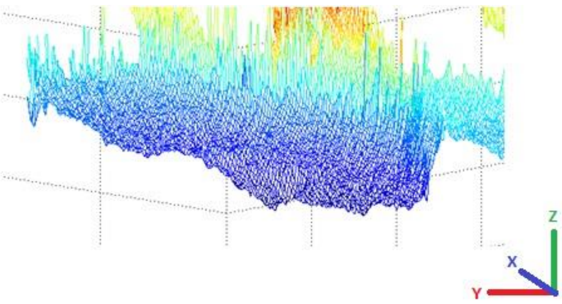

Figure 3. 3D image data early

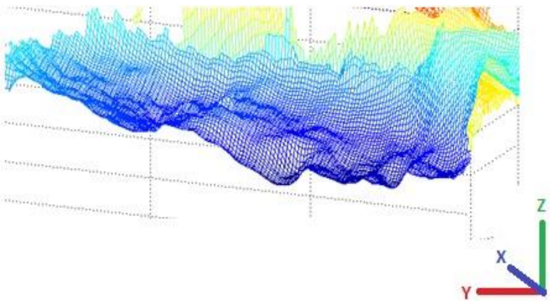

Figure 4. Smooth 3D data

The preliminary 3D image data is the result of data collection using Senz3D camera. Figure 3 shows that the result of the capture still looks rough. In the next stage, the data normalization will conducted by using the following equation,

$$\overline{m} = \sum \frac{\big((x-N:x+N),(y-N:y+N)\big)}{\sum N} \quad (11)$$

where :N=the length of data to be normalized

Figure 4 shows smoother data which later will be used to generate frontal muscle data. By using equation this formula, data with iterations of 2 times generated as follows,

3.1.3. Electromyograph (EMG)

Electromyograph (EMG) is a technique to evaluate the function of nerve and muscle by recording the electrical activity produced by skeletal muscle. Electromyograph (EMG) is used to diagnose abnormalities in muscles and nerves, this is often used to evaluate peripheral nervous system abnormalities. Technique of data retrieval is done by laying electrode on biceps muscle and done by computer recording. The results of the electromyograph will be evaluated by the team of physicians in need.

In a study titled "Electromyographic Signal Identification (EMG) In Motion of Elbow Extension-Flexible Elbow With Convolution Method And Artificial Neural Network" the result of raw data obtained as in Figure 5.

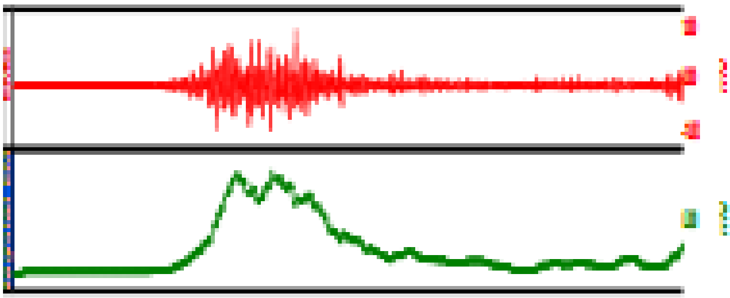

Figure 5. Raw Data Electromyograph (EMG)

In this study discussed about the classification of EMG signals elbow flexion elbow on motion 45^o, 90^o dan135^o with convolution method and artificial neural network. In the study concluded as follows [7],

a. The electromyograph signal has a slightly less amplitude difference, that is 0.242mV on the arm motion signal 45º, 0.253 on the 90º and 0.372mV arm motion signals for the 135º arm motion signal.
b. The signal processing results using FIR Filters yields an average signal output value of 0.0712mV for a 45º, 0.092mV arm motion signal for 90º and 0.163 arm motion signals for a 130º arm motion with an average amplitude decrease of 0.12mV.
c. Optimal artificial neural network parameters to process 2000 EMG signal data points with 3 output category needs are hidden layer 4 neuron and output layer used 2 outputs, learning rate of 0.75 with maximum iteration value of 2000 iterations and an error tolerance of 0.001.
d. The result of signal processing yields 66 unidentified data from 95 total data with details of 18 signal data 45º, 23 signal data 90º and 25 signal data 135º with sum square error equal to 0,0369.

3.2. Examination

This stage conducted in 2 investigations. The first is muscle’s move testing and the second is test of the movement of the muscle.

3.2.1. Muscle’s move testing

The detection of muscle movement will conducted on this stage by using basic muscle works approach. On the muscle works, each contraction will change the shape of the muscle. Firstly the muscle will become shorter and then belli muscle will become bigger. The difference between contraction will be taken with this approach by measuring the space difference on belli muscle. A value of difference in belli will be get by using Euclidean distance formula, if there is difference then the muscle is stated move.

The next step is calculating use GLCM method by counting the matrix scale which has been converted into grayscale data to obtain energy, entropy, contrast, and correlation. The data obtained from the muscle move testing are as the following, from the Figure 6, we can see about the muscle contraction from the motionless to the motion. From this figure, the conclusion is there a contraction in the muscle.

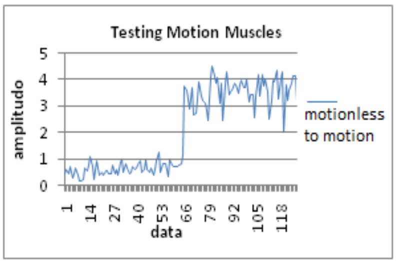

Figure 6. Testing data motion muscles

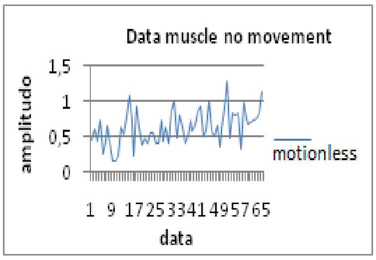

Figure 7. Graph data muscles motionless

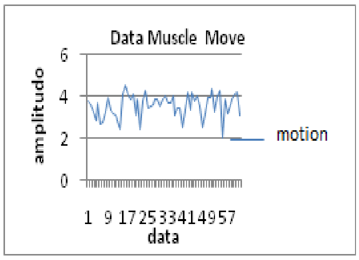

Figure 8. Graph data moving muscles

3.2.2. The Calculation of Muscle Strength

On this stage, the data will be improved by using confidence interval method to determine the interval on the data of normal muscles and move muscles. This data is used to reveal the muscles moving or at rest. The results of these calculations will be tested on model testing to determine the interval data. First, determine the mean value of the data. The result of testing on the moving muscle shows that the data is in interval 0.18 up to 1.24. These data will determine interval of a muscle in a rest or moving. The data of rest muscle can be seen in Figure 7.

Figure 7 is training data for testing the muscle does not move. In the above test, the standard deviation of the rest muscle is 0.236 with a confidence interval "Sy * 1.96" with the confidence assumption of 95% and result obtained of 0.463. Thus, interval of rest muscle is + 0.463 with a mean of 0.635. If the data is still in this area, the data is still declared not move. The calculation of the interval of move muscle is also calculating the interval of that muscle movement. The calculation of the muscle interval also calculated the interval of muscle movement. The move muscle data can be seen in Figure 8.

Figure 8 is the training data of muscle move test. On the test above, the standard deviation from rest muscle is 0.545 with the confidence interval "Sy * 1.96" with the confidence assumption of 95% and gain result about 1.069. The interval of rest muscle is +1.069 with a mean of 3.563. If the data still in this area, data declare as not moving.

4. Conclusion

There are 3 aspect which has been tested at the stage of investigation namely; the testing of muscle movement, the testing of muscle movement shift and testing on 3D models. Based on the test, the conclusion will be explain as below:

a. In the test of muscle movement, there is difference in the numbers of muscle movement. The difference in numbers can be seen in Figure 6. On the testing intervals muscle movement, the mean value of rest muscle is in the range of 0.635 with interval at ±0.463. Whereas, on the move muscles the mean value of the muscle moving is in the range of 3,563 with interval at ±1,069.
b. Testing of the shift of muscle movement can be inferred from the value of the still point range at 0.635 with the lowest interval at 0.172 and the highest interval at 1,098 and a mean value of muscle moves at 3,563 with the lowest interval at 2.465 and the highest interval at 4.632, thus, the shift muscle movement amount of 1.367 up to 4.460.
c. In the accuracy test of a shift in muscle movement, the result of data movement muscle contraction in maximum between 1.367 to 4.460 with the number of data test as much as 7 times 3 trial between the range of 1.367 to 4.460 and 2 data is less than 1,367 and two data more than 4.460. Based on the experimental data, 100% is not in rest range or interval of movement is less than 0.463.

References

[1] Prendergast, Peter M. Anatomy of the face and neck. Cosmetic Surgery. Springer Berlin Heidelberg, 2013. 29-45.

[2] Richfield, David. Medical gallery of David Richfield. *Wikiversity Journal of Medicine*. 2014;1 (2). DOI:10.15347/wjm/2014.009. ISSN 2001-8762
[3] Xie, Zhihua, et al. *Texture image retrieval based on gray level co-occurrence matrix and singular value decomposition*. Multimedia Technology (ICMT), International Conference on. IEEE. 2010.
[4] Pullaperuma PP, AT Dharmaratne. *Taxonomy of File Fragments Using Gray-Level Co-Occurrence Matrices.* Digital Image Computing: Techniques and Applications (DICTA), International Conference on. IEEE, 2013.
[5] Kasim, Anita Ahmad, Agus Harjoko. *Klasifikasi Citra Batik Menggunakan Jaringan Syaraf Tiruan Berdasarkan Gray Level Co-Occurrence Matrices (GLCM).* Seminar Nasional Aplikasi Teknologi Informasi (SNATI). 2014; 1(1).
[6] Thakare, Vishal S, Nitin N Patil. *Classification of texture using gray level co-occurrence matrix and self-organizing map.* Electronic Systems, Signal Processing and Computing Technologies (ICESC), International Conference on IEEE. 2014.
[7] Rokhana, Rika. *Identifikasi Sinyal Electromyograph (Emg) Pada Gerak Ekstensi-Fleksi Siku Dengan Metode Konvolusi Dan Jaringan Syaraf Tiruan.* Industrial Electronic Seminar. 2009.
[8] Igor Juricevic, Michael A. Webster, *Selectivity of Face Aftereffects for Expressions and Anti-expressions*. Frontiers in psychology. 2012.
[9] Scott L. Delp, J. Peter Loan, A Computational Framework for Simulating and Analyzing Human and Animal Movement. *IEEE*. 2000.
[10] Minarno, Agus Eko, Arrie Kurniawardhani, Fitri Bimantoro. Image Retrieval Based on Multi Structure Co-occurrence Descriptor. *TELKOMNIKA (Telecommunication Computing Electronics and Control).* 2016; 14(3): 1175-1182.
[11] Minarno, Agus Eko, Nanik Suciati. Batik image retrieval based on color difference histogram and gray level co-occurrence matrix. *TELKOMNIKA (Telecommunication Computing Electronics and Control)*. 2014; 12(3): 597-604.
[12] Sobotta, Johannes. Sobotta's Atlas and Text-book of Human Anatomy. 1909.
[13] Jacobo Bibliowicz. An Automated Rigging System for Facial Animation. Cornell University, 2005