Recognition of Hand Movement for Training Motor Skill of Children With Autism Spectrum Disorder (ASD) Using Myo Gestures Control Armband and Artificial Neural Network

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Abstract. Autism disorder causes sufferers to tend to lag behind other children in understanding and accepting the stimuli given, due to the patient's inability to focus attention on the stimulation given. One of the therapies used to train autistic sufferers is the help of technology. One of the technologies used is the Myo Gestures Control Armband which is equipped with several sensors that can recognize hand and arm movements using the Artificial Neural Network method which adopts a thought through a mechanism that affects the human brain, both for processing various signal elements received, tolerance of errors, and also parallel processing. In this study, there are five movements classified as Ok, Fist, Like, Rock, and Spock movements to train motor movements of children with autism. With this system in the future it can become a method of therapy that is carried out at home with the supervision and control of a therapist so that it can improve the development of hand motor skills in children with autism which can be seen through a graph of the development of movements per day displayed on the system.

1. Introduction
Autism is a syndrome caused by nerve damage. This disease can interfere with motor development in children and adults. The diagnosis of autism is known from the symptoms that appear, which is indicated by the presence of developmental disorders [1]. Autism disorder causes sufferers to tend to lag behind other children in terms of understanding and accepting stimuli or materials provided by teachers at school, caused by the child's inability to focus attention and focus on the stimuli provided [2] [6] [7]. Various types of therapy have been developed to develop the ability of people with autism to live. Almost all sufferers experience delays in motor development. Their movements are stiff and rough, they have difficulty holding a pencil in the right way, have difficulty holding the spoon and feeding food into their mouths, and other movements.

Motor neurons are nerves that play a role in increasing a person's ability to do something with small muscles [3]. One of the therapies used to train motor children with autism can be done by using technology. To train hand muscle strength in children with autism it is necessary to do movement training. Hand movement training for children with autism can be done using hand motion recognition technology. One of them is the Myo Gestures Control Armband which is equipped with several sensors that can recognize hand movements and arm movements. By using a process called electromyography (EMG), which has a working mechanism of identifying signals by moving muscle muscles, 8 EMG sensors are responsible for recognizing and performing each movement. [4] [5]. For the recognition of hand movements, the Artificial Neural Network method is used, which is an information processing
system that has characteristics similar to biological neural networks [7]. Therefore, this research aims to design an application with Myo Gestures Control Armband by implementing Artificial Neural Networks with the aim of supporting the enhancement of motor neurons in children with autism.

2. Methodology
Methodology is a series of activities carried out in research so that it can be seen clearly the work flow of the things that must be done in the research. In these research, there are several process which are described in Figure 1 below with a brief explanation of the processes that occur at these stages,

![Figure 1. Methodology](image)

2.1 Input
First process of the research was the collection of a dataset derived from EMG data set. These data sets contains hand movements taken using a data recording application Myo Gesture Control Armband which consists of eight channels and arranged into 64 Channels per row, this data set has CSV (Comma Separated Value) format. Dataset has collected and divided into two parts are training data and testing data.

2.2 Recognition
In the EMG data process, there are some unnecessary data contained in the dataset, so there is a need for a cleaning process on the dataset by eliminating unnecessary data in the form of Gyroscope, Orientation, and Accelerometer data so that only emg data is taken. The following is an example of a dataset image that has undergone a process before and after data cleaning which can be shown in Figures 2 and 3. After EMG data process, next process is feature extraction In this process, the EMG data cleaning process is carried out using the MAV function for get the absolute average of the EMG signal amplitude in each segment. In this research, we use two types of feature extraction, MAV and RMS.
2.3 Classification

In the classification process, the types of hand movement are carried out using the artificial neural network method. The classification results of hand movements using myo arm band resulted in 5 hand movements consisting of OK, Fist, Like, Rock, Spock. The backpropagation network training steps uses 2 input neurons, 3 neurons hidden and 1 output neuron will be described as follows:

a. Data with input X1 (Value EMG data), X2 (label of each EMG data) and target, previously the data has entered into feature extraction, where the data in the process to make the data into a lower dimension as shown as Table 1.

| Data     | X1  | X2  | t(target) |
|----------|-----|-----|-----------|
| Abilify  | Discmelt | 0,44 | 0,41      |

b. Initialize the initial weights with a value between 0 and 1

- Initiate the connection weights between the input layer (Vi) and the hidden layer (Zi) as shown in Table 2.

| V1,0 (bias) | V2,0 (bias) | V3,0 (bias) | V1,1 | V2,1 | V3,1 |
|-------------|-------------|-------------|------|------|------|
| 0,172       | 0,128       | 0,453       | 0,767| 0,143| 0,508|
| 0,128       | 0,128       | 0,143       | 0,143| 0,143| 0,508|
| 0,453       | 0,508       | 0,44        | 0,767| 0,143| 0,508|

- Initiate the connection weights between each hidden layer (Wi) and output neuron layer (Y). As shown in Table 3.

| W1,0 | W1,1 | W1,2 | W1,3 |
|------|------|------|------|
| 0,457| 0,855| 0,165| 0,311|

c. Determine the value of the learning rate parameter and the maximum epoch i.e learning rate (α): 0.1 and maximum epoch: 10.
d. Do iteration for epoch < maximum epoch.
e. Do the forward phase steps

- Calculate the Znetj value on the hidden layer
  
  $Z_{net1} = X_0 * V_{1,0} + X_1 * V_{1,1} + X_2 * V_{1,2}$
  
  $= 1 * 0.172 + 0.44 * 0.767 + 0.4 * 0.332$
  
  $= 0.172 + 0.33748 + 0.1328 = 0.64228$
  
  $Z_{net2} = X_0 * V_{2,0} + X_1 * V_{2,1} + X_2 * V_{2,2}$
  
  $= 1 * 0.128 + 0.44 * 0.143, + 0.4 * 0.261$
  
  $= 0.128 + 0.06292 + 0.132 = 0.64228$
  
  $Z_{net3} = X_0 * V_{3,0} + X_1 * V_{3,1} + X_2 * V_{3,2}$
  
  $= 1 * 0.453 + 0.44 * 0.508 + 0.4 * 0.132$
  
  $= 0.453 + 0.22352 + 0.132 = 0.72932$

- Then calculate the Zj output value on the nodes in the hidden layer using the activation function, in this example using the function sigmoid activation.
  
  $Z_1 = \frac{1}{1+e^{-Z_{net1}}} = 1/1+e^{-0.64228} = 1/1+0.526 = 0.655$
  
  $Z_2 = \frac{1}{1+e^{-Z_{net2}}} = 1/1+e^{-0.64228} = 1/1+0.526 = 0.655$
  
  $Z_3 = \frac{1}{1+e^{-Z_{net3}}} = 1/1+e^{-0.72932} = 1/1+0.482 = 0.675$

- Calculate the $y_{net}^k$ value on the nodes in the output layer
  
  $y_{net1} = Z_0 * W_{1,0} + Z_1 * W_{1,1} + Z_2 * W_{1,2} + Z_3 * W_{1,3}$
  
  $= 1 * 0.457 + 0.607 * 0.875 + 0.177 * 0.569 + 0.648 * 0.314$
  
  $= 0.457 + 0.531125 + 0.598588 + 0.203472 = 1.790185$

- Then calculate the $y_{net}^k$ output value at the node in the output layer using the sigmoid activation function
  
  $y_{net1} = \frac{1}{1+e^{-y_{net1}}} = 1/1+e^{-1.790185} = 1/1+0.167 = 0.857$

f. Do the backward phase steps

- Calculate the factor $\delta$ in the unit of output $y_k^\delta$
  
  $(1 - y_1) y_1 (1-y_1) = (1-0.78) * 0.78 (1-0.78) = 0.22 * 0.78 * 0.22 = 0.03$

- Calculate the term change in weight $W_j^k$ (hidden layer weight value to output layer)
  
  $\Delta W_{1,0} = 0.1 * 0.03 * 1 = 0.003$
  
  $\Delta W_{1,1} = 0.1 * 0.03 * 0.607 = 0.0018$
  
  $\Delta W_{1,2} = 0.1 * 0.03 * 0.569 = 0.0017$
  
  $\Delta W_{1,3} = 0.1 * 0.03 * 0.648 = 0.0019$

- Calculate the sum of $\delta_{net}^j$ in the hidden unit $Zj$
  
  $\delta_{net1} = \delta_1 * W_{1,1} = 0.03 * 0.855 = 0.02565$
  
  $\delta_{net2} = \delta_1 * W_{1,2} = 0.03 * 0.165 = 0.00495$
  
  $\delta_{net3} = \delta_1 * W_{1,3} = 0.03 * 0.311 = 0.00933$

- Calculate the factor $\delta$ in the hidden unit
  
  $\delta_1 = \frac{\delta_{net1}(1-Z_1)}{0.02565 + 0.655 (1 - 0.655)} = 0.02565 * 0.655 * 0.345 = 0.0058$
  
  $\delta_2 = \frac{\delta_{net2}(1-Z_2)}{0.0495 * 0.655 (1 - 0.655)} = 0.0495 * 0.655 * 0.345 = 0.00119$
  
  $\delta_3 = \frac{\delta_{net3}(1-Z_3)}{0.00933 * 0.675 (1 - 0.675)} = 0.00933 * 0.675 * 0.325 = 0.00205$

- Calculate the terms of change in weight $Vij$ (the value of the input layer weight to hidden layer)
  
  $\Delta V_{i,j} = \alpha * \delta * X_i$
  
  $\Delta V_{1,0} = 0.1 * 0.006 * 1 = 0.0006$
  
  $\Delta V_{1,1} = 0.1 * 0.006 * 0.1 = 0.00006$
  
  $\Delta V_{1,2} = 0.1 * 0.006 * 0.556 = 0.0003336$
  
  $\Delta V_{2,1} = 0.1 * 0.013 * 1 = 0.0013$
  
  $\Delta V_{2,2} = 0.1 * 0.013 * 0.1 = 0.00013$
  
  $\Delta V_{2,3} = 0.1 * 0.013 * 0.556 = 0.0007228$
  
  $\Delta V_{3,1} = 0.1 * 0.002 * 1 = 0.0002$
2.4 Output
Output produced in this system is in the form of real time hand gesture recognition based on emg data which obtained from the Myo Gesture Control Armband used by user. The resulting movements are OK, Fist, Like, Rock and Spock. Apart from identifying five movements, the system will display relax movements for movements that are not recognized by the system.

3. Results and Discussion
This application menu display is a main menu from system which there are icon of myo gesture control armband. In this page there is icon of diagram which can show many movements have done, chart can show data for up to a month or more. The application menu display and sub menu contained in it can be seen at figure 4 and 5.

Before recognition movement of hand, user required to connect Myo Gestures Control Armband device to PC via Bluetooth Dongle then system will be able to continue running process system. As for the position of the use from the tool and examples of movements that can be predicted can be seen in Figure 6 to 10.
When user using Myo Gestures Control Armband tool, system will display as shown in Figure 11 to 15 according to user movements.

![Figure 11. Fist Motion](image)

![Figure 12. Ok Motion](image)

![Figure 13. Like Motion](image)

![Figure 14. Rock Motion](image)

![Figure 15. Spock Motion](image)

Application testing was carried out on a 16 year old autism sufferer with a cure rate of 70%. Users test the system by performing 5 movements in 1 minute with an average of 200 movements. As for movements obtained from this first test can be seen in Table 4.

| No | Name Movements       | Total Movements |
|----|----------------------|-----------------|
| 1  | Relax/Movements 0    | 480             |
| 2  | Fist/Movements 1     | 50              |
| 3  | Ok/Movements 2       | 150             |
| 4  | Like/Movements 3     | 70              |
| 5  | Rock/Movements 4     | 200             |
| 6  | Spock/Movements 5    | 50              |

From the results of the tests carried out as shown in Table 4, accuracy value obtained after each movement as many as 200 movements and have a user case experiencing autism with the system motor skills are weak, getting an average percentage value of 83.3%.
For every movements that have been done by user will be stored in database then displayed on a progress chart as shown in Figure 16. In this graph there are six records of movement data which consist of: Relax, Ok, Fish, Like, Rock and Spock. The gesture display will be displayed with different colors.

In addition to testing with autism children, expert testing is also performed to see the success of the system to produce accurate outputs in accordance with the research objectives by asking some question related with system to the therapist.

| No | Question                                                                 | Disagree | Agree | Strongly agree |
|----|--------------------------------------------------------------------------|----------|-------|----------------|
| 1  | Is existing therapy in system can be companion therapy than other therapies? |          |       | ✓              |
| 2  | Is existing therapy in the system can make progress in autism sufferers?  |          | ✓     |                |
| 3  | Is application easy to use?                                              |          | ✓     |                |
| 4  | Is these application can be as an application therapy for autism sufferers? |          | ✓     |                |
| 5  | Can the application run properly?                                        |          | ✓     |                |

4. Conclusion
Based on the test results using the Myo Gestures Control Armband tool, in Recognition hand movements, there are several conclusions:

a. System testing conducted on children with autism has resulted that system running well in the predetermined movements recognition which the best results obtained using the respective rules.
in of 200 movements, the highest proportion accuracy is obtained 97.3% with cases of users before wearing MYO Gesture Control Armband do activities such as typing and lifting books. Which one movement that has value lies in the Spock motion, and the most movement that can be performed with the highest score is the Fist motion.

b. The size of the movement that can be classified depending on the activity on user and muscle mass which is beyond mass of muscle in general.

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