Implementation of Myo Armband on Mobile Application for Post-stroke Patient Hand Rehabilitation

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***Abstract*— Medical rehabilitation is one of the efforts to restore motor function of post-stroke patients, but the biggest factor that makes patients quickly restore motor function by active patient movement exercises. The movement in question is the movement carried out every day outside medical rehabilitation at the hospital. On the other hand, patients are reluctant to do therapy independently outside the hospital, because there is no tool that supports patients to do so. So, we need a device that helps patients to do therapy independently. The device is connected to Myo Armband to read the gestures of the patient by looking at the EMG signal from the patient's hand. Then the system performs matching gestures during therapy with EMG signal data that has been trained. The motion matching is done by calculating the Euclidean distance between the two EMG signal data obtained from the Myo Armband device. From the results of the tests carried out, the accuracy of movement matching results obtained an average accuracy of 89.67 percent for flexion-extension gestures and 82 percent for pronation-supination gestures. It can be concluded that Myo Armband in the Mobile Application can be used for Rehabilitation of post stroke patient hands.**

Keywords—Rehabilitation, EMG Signal Myo Armband, Post-Stroke

I. INTRODUCTION

Cerebrovascular accident (CVA) is a disease that is often classified as a deadly disease in Indonesia with 15.9 percent of the causes of death in Indonesia [1]. The World Health Organization (WHO) defines stroke as a rapid onset of clinical symptoms disruption of cerebral function with a symptom lasting 24 or more hours without any apparent power other than from the vascular system [2].

According to data of the Ministry of Health of the Republic of Indonesia, the number of stroke patients in Indonesia in 2013 based on the diagnosis of health workers (Nakes) is estimated as 1,236,825 people (7.0 ‰), while based on diagnosis / symptoms are estimated as many as 2,137,941 people 12.1 ‰) [1]. The data is very large for developing countries like Indonesia and each year the number of stroke patients continues to increase with the unhealthy lifestyles of modern society and underestimate the healthy diet and causes of other stroke.

However post-stroke patients can restore their motoric function by performing regular and regular rehabilitation. Post-stroke rehabilitation is usually performed only in hospitals that have medical rehabilitation facilities with physiotherapy or doctors. Whereas to restore the patient's motoric function efficiently the patient must perform active patient gestures every day outside the rehabilitation time in the hospital. The patient's active motion is self-directed gesture by the patient. It is expected that by actively conducting physical moving the patient in his spare time to increase the level of muscle reconstruction can occur maximally.

The development of tools for post-stroke rehabilitation patients began to emerge much like saddle designs for bicycle stroke patients. Another example is Myo Armband. Myo armband is a device developed by Thalmic Labs company. Myo armband is a bracelet device used on the human arm to identify gesture of arm muscles by using electromyography technique. In addition to the EMG sensor, Myo Armband is also powered with several Accelerometer sensor, Gyroscope, and Magnetometer combination of the three sensors with the Inertial Measurement Unit (IMU) [3]

The research developed a new method for post-stroke patients. The aim of this research is to create an application that helps post-stroke patients in recovering their hands. This will be done with the Myo Armband device used to detect post-stroke patient gesture.

II. SUPPORTING THEORY

A. Post-Stroke Rehabilitation

Rehabilitation is a program designed to recover sufferers with physical distress and / or chronic diseases, so that they can live or work fully in their capacity. Post-stroke rehabilitation aims for stroke sufferers to live independently and productively again. The success rate of post-stroke rehabilitation depends on several aspects, ranging from the extent of brain damage, early handling time, the role of the family, and methods for therapy. Post-stroke rehabilitation therapy is divided into several kinds, ranging from motion exercises, tool modalities, drugs, and psychology [4].

In this research, the authors used post-stroke type of rehabilitation with motion exercises. The motion exercises taken are wrist movement exercises, in which the movement is two wavelengths of flexion-flexion and pronation-supination. The following describes flexion-extension and pronation-supination gestures.

- flexion-extension, i.e wrist movement to the inner side and move the hand back again straight
- pronation-supination, i.e moving the wrist down and back up again.

B. *Manual Muscle Testing (MMT)*

Manual Muscle Testing (MMT) itself is one effort to determine or know one's ability to contract muscle or muscle group involuntary. MMT is one of the most popular muscle strength measurement methods and is mostly done by physiotherapy. In MMT, strength is measured on a scale of zero to five points. Table I is the MMT scale and its description.

TABLE I. MANUAL MUSCLE TESTING

Number	Scale	Explanation
1	0	Muscle contraction is undetectable
2	1	The presence of muscle contraction and no movement of the joints
3	2	The presence of muscle contraction and the movement of joints full ROM
4	3	The presence of muscle contraction, the movement of joints full ROM and able to resist gravity
5	4	The presence of muscle contraction, the movement of joints full ROM, able to fight gravity dam minimum resistance
6	5	Ability to resist maximum resistance

In the medical world of post-stroke patients is very complex, in a thousand cases of stroke that each of them is different and unique to each other. So that the handling of rehabilitation must also be done differently to every patient. Therefore, the application is a limited to user who will use the application later. The application will be used for rehabilitation with post-stroke patients with lower arm muscle weakness and Manual Muscle Testing (MMT) more than two.

III. SYSTEM DESIGN

System design includes the process of making and running applications from the use of Myo Armband hardware, therapeutic process and application functionality until the applied system diagram.

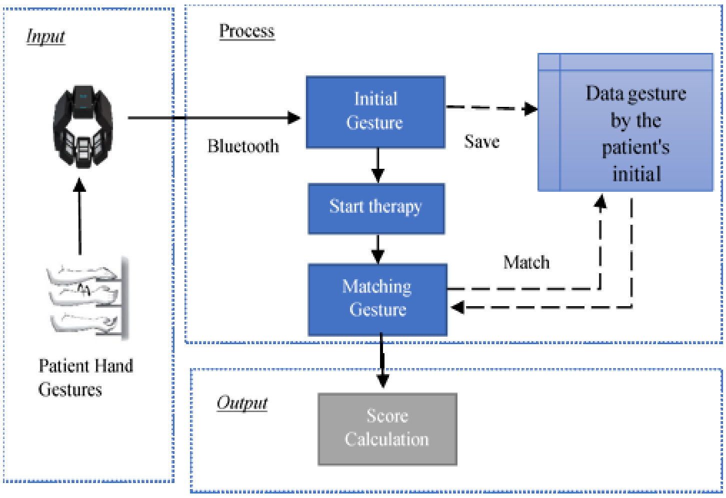

Fig. 1. Diagram System

Figure 1 illustrates the system design block and how the application runs. In general, the system is divided into three stages of input, process and output.

A. *Input*

The input of the hand-therapy application system is the gestures of the patient's hand during a therapeutic motion or not a treatment motion as shown in Table 2. The gesture will then be read by Myo Armband using eight EMG sensors in the device. Given in Myo Armband itself there are some sensors, but researchers only use EMG sensors, because in the therapy system built by the patient's hand does not move coordinately, so the IMU sensor in Myo Armband is not needed.

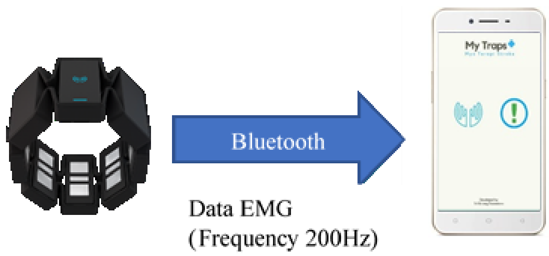

Fig. 2. Communication between devices

The data from myo armband will be sent to the android application using Bluetooth communication. In sending data from the myo armband device to the android application there is a distinction between EMG data and IMU data, where EMG data is flown at 200 Hz frequency while IMU data at frequency 50 Hz. Smartphone used must meet the development requirements of the android version of the Myo android version of SDK.

- The smartphone device must have Bluetooth Low Energy (BLE).
- Android version 4.3.

B. Process

In the application process of this therapy there are several parts that will be run later. Such parts include early therapeutic motion, early gesture storage therapy, initiation of therapy and matching therapeutic gestures. Here's an explanation of each part of the therapy application process.

1) Early gesture taking : Once the application can capture the gesture of the patient, then the patient can perform a series of therapies made by researchers. The first thing to do before the therapy in the application begins, patient performs recording or retrieval of early motion data. Each will initiate a series of therapies, the patient must be required to perform initial motion data capture first. Gestures taken based on the motion of therapy performed by patients with gesture as in Table 2 depends on the type of gesture and step chosen by the patient.

TABLE II. GESTURE MODEL ILUSTRATION

Type of Gesture	Step	Gesture Model Illustration
Flexion - Extension	1	
	2	
	3	
	4	
Pronation-Supination	1	
	2	
	3	
	4	

2) Storing of early gesture: After the patient performs the initial gesture of therapy, the application will store the data on a document that is in the internal memory of the smartphone. So the data is easily accessible by the system when matching the gesture later. The type of document used will be of type .dat. The data stored from the patient's gesture is the value of the eight EMG sensors in Myo Armband device, so there are eight data to be stored.

3) Starting therapy: When the patient has completed the initial gesture and the gesture data has been stored, the patient can begin therapy, the patient will do the therapy by performing gestures as in Table II and the repetition like the gesture as much as the predetermined number is the number 30.

4) Gesture matching: Figure 3 is a flowchart of gesture matchings that exist in the hand-made therapeutic application.

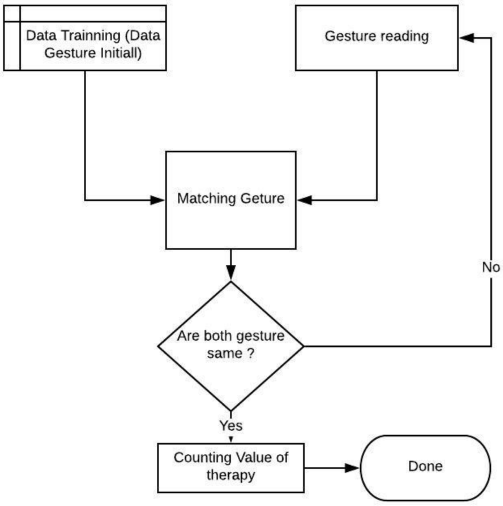

Fig. 3. Flowchart of gesture matchings

The data obtained when the patient performs the initial gesture will be used as training data (x) and motion data will be used as data testing (y). In determining the classification of whether the two gestures are the same or not, the approach by calculating the distance between the two data is called the euclidean distance. Here is the equation of Euclidean distance calculation on the equation 1.

$$D\,(x, y) = \sqrt{\sum_{i=1}^{d} (x_i - y_i)^2} \qquad (1)$$

Where D (x, y) is the Euclidean distance or the distance between the two data is x and y. x is the preliminary gestures data of therapy and y is the patient's gestures therapy data. The two variables that are to be classified and i represent the attribute value and n is the attribute dimension. If both data are known the distance between the two then the next system will group the two data together or not. To determine the level of similarity of researchers using tolerable Euclidean distance limitations.

C. .Output

The final stage of the system created is output. The output of the created system will then display the value or the therapeutic score, this value is made based on the same amount of gesture performed by the user during therapy with the gesture before the therapy or gesture taken from the beginning before the therapy or in other words the correct calculation of gesture preliminary gesture data. So, if the patient does a lot of the same gesture with the initial gesture, then the value will continue to multiply as well. One gesture of equal value will increase one. The calculation will end if the patient reaches a value of 30. Flowchart calculation of the score or score as in the picture.

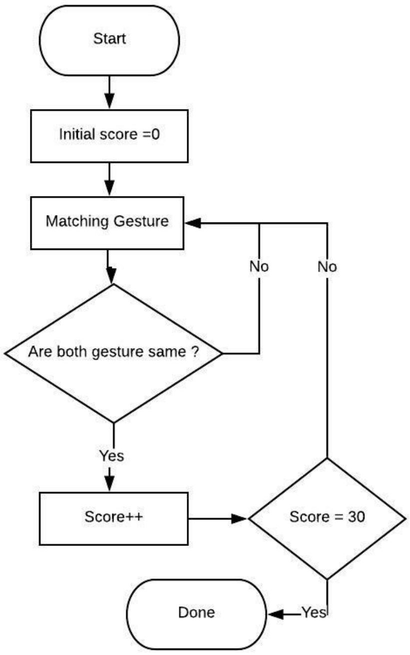

Fig. 4. Flowchart calculation of the score therapy.

Value or score later will be used as a reference for patients to stage therapy (step) or not. The selection of 30 is based on the usual repetition of hospital-based therapies with details of three sets of exercises and each set is ten times the repetition of gesture. In addition to seeing the value achieved by the patient during therapy, the patient's decision to proceed to the next step is determined by the doctor or physiotherapist who handles the patient later.

IV. Result And Discussion

The applications that have been developed are tested to suit the use in real life. The test conducted in this study is testing about the interface display of the application and matching the gestures performed.

The user interface of the application is tested using multiple users with several types of user mobile devices, where this test is to determine the response of the user interface that is made to adjust the state of the mobile device. For the example whether the display of buttons and images can adjust from the layer resolution on a mobile device. The following Figure 5 is the result of the application user interface design.

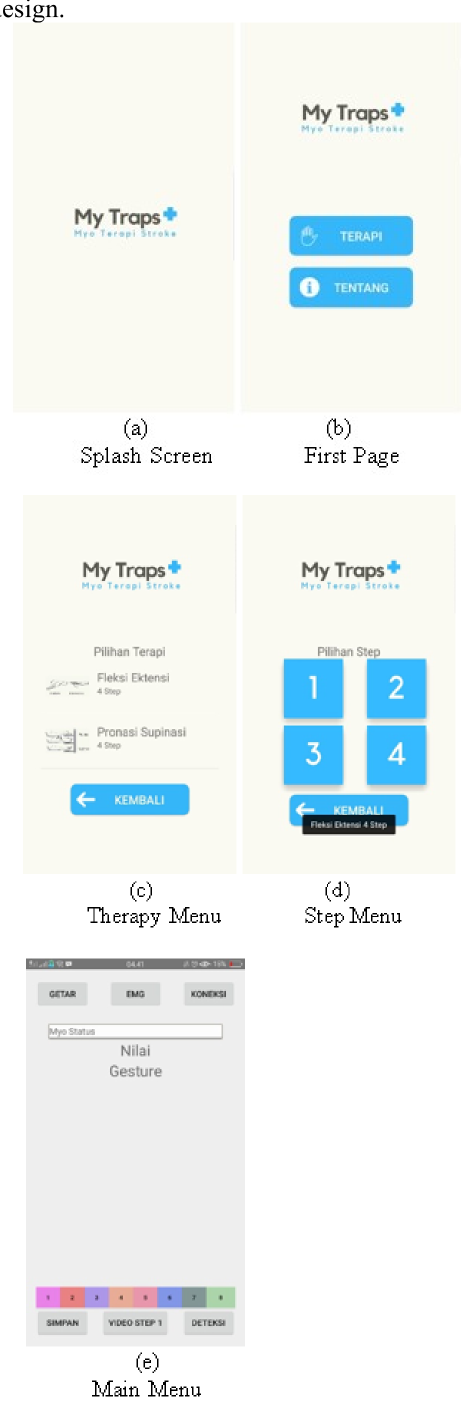

Fig. 5. User interface application.

The user interface test results show that the design is very responsive to other mobile devices. In the application, researchers use Indonesian in the language used, because most users will be Indonesian.

The trial conducted by the next researcher was to test the classification of the forearm movement on users at the Airlangga University Hospital.

The movement being tested is a therapeutic movement consisting of two gestures, including flexion-extension and pronation-supination. Each movement has three types of motion, namely maximum, middle, and relaxed. Each movement was carried out repetition of motion 10 times so that a trial of 30 gestures was obtained. For testing the classification of gestures the researcher took data from 10 users. The following figure 6 is a sensor reading on the flexion motion.

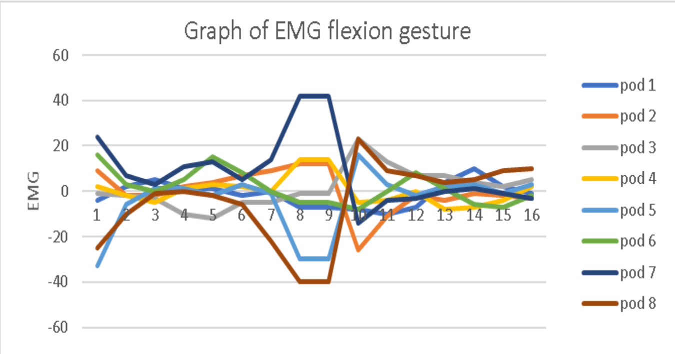

Fig. 6. Graph of EMG flexion gesture.

The researcher carried out 16 EMG sensor data collection in each EMG sensor. It can be seen in Figure 6 the value of the EMG sensor when the user moves, the highest value can reach 42, then the form of each signal on the EMG is almost the same as each other. The following figure 7 is a sensor reading on the pronation motion.

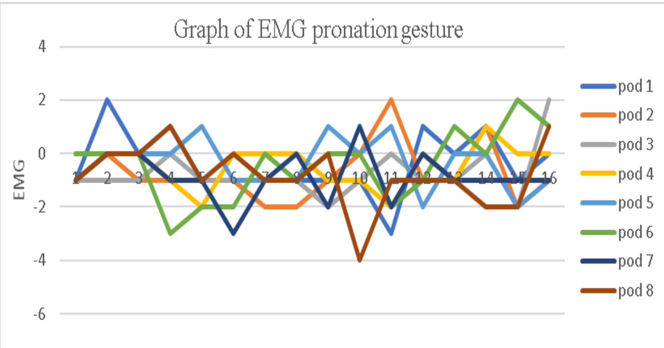

Fig. 7. Graph of EMG pronation gesture.

After the user moves, the researcher records the correct and wrong gestures from the system reading about the user's motion detection. Then the accuracy level of the motion detector is calculated. The formula for calculating accuracy is shown in Equation 2.

$$\text{Accuracy} = \frac{\text{total correct Gesture}}{\text{total overall Gesture}} \times 100\% \quad (2)$$

After calculating the accuracy of the data obtained the accuracy of the movement of each user and the average accuracy of the movement of each movement. The following table 3 is the result of calculating the accuracy of each user in flexion-extension gestures

TABLE III. CALCULATING THE ACCURACY FLEXION

Number User	Accuracy
1	83.333%
2	86.67%
3	96.67%
4	93.33%
5	86.67%
6	93.333%
7	83.333%
8	93.33%
9	100.00%
10	80.00%
Average accuracy	**89.667%**

From table 3 it can be seen that the average flex-extension motion matching accuracy results are 89,667 percent of 10 users. Where the smallest accuracy of ten users is 80 percent and the highest reaches 100 percent success in detecting the movement of the user's hand. Next table 3 is the result of calculating the accuracy of each user in the pronation-supination movement.

TABLE IV. CALCULATING THE ACCURACY PRONATION

Number User	**Accuracy**
1	86.67%
2	83.33%
3	93.33%
4	83.33%
5	80.00%
6	63.33%
7	86.67%
8	76.67%
9	73.33%
10	93.33%
Average accuracy	**82.00%**

Table 4 shows the level of accuracy of the system in detecting pronation-supination gestures carried out by ten users. From the level of accuracy, the average accuracy value is 82 percent. Where the average accuracy is lower than the average accuracy of flexion-extension gestures. Due to the muscles that work when pronation-supination moves more towards the upper arm muscles instead of the forearm.

V. Conclusion And Future Work

Myo Armband on a mobile application can be used to match patient gestures during therapy. The average level of application accuracy in user movement matching is 89.67 percent for flexion-extension gestures and 82 percent for pronation-supination gestures. Based on the results of the experiment, it can be concluded that Myo Armband in a mobile application can be used as a new tool to help the rehabilitation of the hands of post-stroke patients. In the future, researchers will try application devices to be used by patients directly so that researchers can find out the level of comfort, ease and ergonomics of the application to the rehabilitation of post-stroke patients

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