Comparison of Neural Network Algorithms to Determine the Range of Motion using Skeleton Models

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***Abstract* - We have the main characteristics of moving as walking, running, sitting, dancing, eating, drinking and other activities. The range-of-motion, ROM, is the maximum number of movements that can occur in the sagittal, frontal, and transverse type and consists of flexion, extension, abduction, adduction, hyperextension and others. Decreased ROM can be the result of injury and the aging process and can lead to undesirable motion patterns. Feature extraction in motion analysis involve calculating a number of characteristic values independent of the size to produce the appropriate motion identification using the best method or algorithm during processing. Based on the data types obtained from the process of extracting properties collected using moment invariance, the results of identification based on ROM standard gave an accuracy of 98% using Back propagation Neural Network, 94% using Radial Basis Function Neural Network and 36% using K Means Clustering.**

Keywords* - *Neural Network, Process Identification, Range of Motion

I. INTRODUCTION

The Range of Motion (ROM) defines the maximum number of movements that can be carried out in sagittal, frontal, and transverse types and consists of rehabilitation of flexion, extension, abduction, adduction, hyperextension of body and other types of motion. Based on medical classification of ROM, it may consist of active ROM and passive ROM. Active ROM therapy is a type of motion when there is muscle weakness in the arms, shoulder or leg muscles and other muscle exercises in the form of flexion due to injury. Injuries become a risk for anyone who performs these exercises such as athletes. Passive ROM is a clinical exercise that can be performed alone, when the limbs are affected and injured.

In sports for example, every movement performed by related athletes to the sphere of motion (Range of Motion) greatly affects the pattern and form of motion that is done by the athlete. If the motion is done by the movement doesn't meet standard of ROM (Range of Motion) it is clear that there is a decrease in the function algorithm of the motion performed, if the range is carried out from the motion perform then is visible also the decrease activities and achievement rehabilitation athlete. A decrease can be seen in the absence of motion of the range which is existence of injury movement. A decrease in ROM may also cause undesired things such as the accurate of a permanent motion. Research conducted for testing processes related human body motion analysis can be used to determine motion abnormalities in relation to physical medicine and medical rehabilitation.

II. LITERATURE RIVIEW

Gestural analysis is urgently needed to assist medical professionals in physiotherapy for patients experiencing abnormalities in motion such as simple exercise therapy for hand and joint motion, [1]. The ability of individual motion has several criteria that can be reviewed from the flexibility, balance, coordination, strength and endurance of gestures performed by human Research conducted diagnosed visualization of the flexion movement, abduction and adduction clinically [2]. Related research is also used to identify the type of movement associated with the Range of Motion (ROM) in the form of motion can only provide the process of motion types has not discussed the value of algorithm which related analysis, creating a game with the healing process and rehabilitation movement on the shoulder type of movement performed flexion motion abduction, adduction and internal rotation. [3]. Related research using combination propagation neural network and pattern recognition process using Artificial Neural Network by performing movement on the type of abduction, adduction and flexion, the accuracy value is about 85% [4].

Similar research, related to the type of motion analysis on the shoulder movement with hand motion identification. [5]. The process of classification and identification using pattern recognition can provide an alternative solution for recognizing, the specific characteristics of motion, through the process of recording devices, an early stage acquisition of image processing, [6]. Digital image processing is used to study matters relating to image quality improvement, perform the selection of image feature those are optimal for

the purpose of analysis, making the process of information. [7]. Associated with the identification and extraction of information contained in the image of this pattern, there extraction process features performed, the feature extraction on image processing is used to perform the recognition and classification process of human motion, [8]. Feature extract motion analysis involves calculating a member of characteristic values independent of the size to produce the corresponding motion identification using the best algorithm, [9]. In the performed research with a skeleton tracking process using grayscale depth, skeleton detection and feature extraction with Straight Leg Raise and accuracy 94.54% and not using moment invariant, [10].

The extraction process uses temporal convolution networks, ankle and pelvic extracts, using dataset and 83.1% accuracy but have not identified motion based on Range of Motion and have not used invariant and artificial neural network, [11]. Based on research has variant done previous researcher movement have not use real data (primary feature data), not identify type movement by using Range of Motion and not implement the method moment invariant, Back Propagation Neural Network, Radial Based Function Neural Network and K Means Clustering.

III. PROPOSED METHODS

A. Subjects

First we describe the research methodology used to develop the Artificial Neural Network methods which combines the use of moment invariant as one of the methods for feature extraction. The method is developed based on previous studied which has been presented in introduction. The research method can be explained in figure 1. The methodology of research conducted with early stage, prepared actors who will serve as the object of human beings in the process of retrieval of gestures. The process of data acquisition is performed using the camera resolution 20.1 MP. The data in the form of a video that contains the motion on the position of the body anatomically based on frontal or coronal areas.

The result of the acquisition of human objects with the motion of the process consists of a series of image frames with a total of 30 frames per second. on each frame extraction results then do image processing to detect the type of motion of the human body (including the scope of the motion of Joints/Range of Motion in the field of anatomical human body by identifying the motion of the abduction, adduction, extension, and flexion type which corresponds to the movement of the human shoulder). Image segmentation is carried out using the method of background subtraction, namely for separating a foreground (object of the motion of the human body from the field of anatomically) and background (object other than humans).

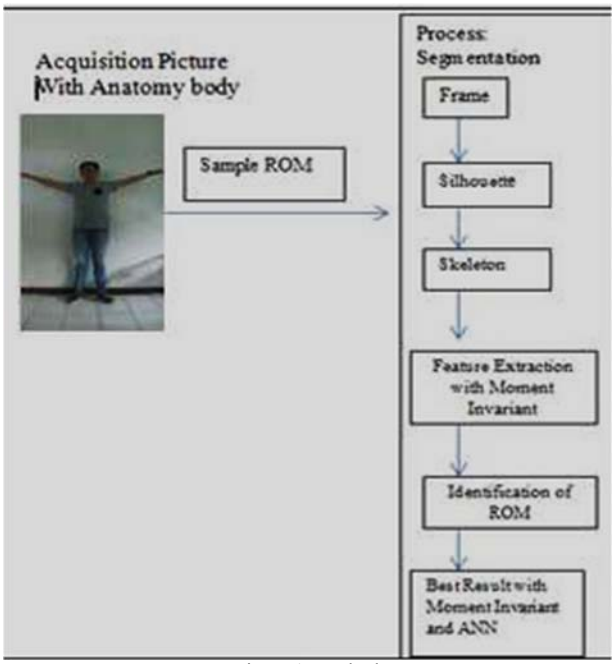

Figure 1. Method

The next step is to convert a grayscale image into binary image subtraction results through the operation threshold, perform the operation of binary image against morphology form filling holes and areas closing to remove noise and improve results segmentation for the process of making silhouettes. Then do the skeleton binary image segmentation results against. After the objects in the image are separated with his background, the further done the stages of extraction characteristics.

The extracted characteristics used to differentiate types of motion between the object of one's body with the object of other bodies such as anatomical body position on the motion based on the areas of the frontal or coronal planes. Study on the extraction of characteristics is done through the analysis of the morphology (shape) based on invariant moment value seven These values are extracted from each image to differentiate the output class 8 (on a temporary trial data) that the class no class object, flexion, extension, abduction, adduction hyperextension, horizontal extension as well as other human shoulder motion. The seven values of the moment unchanged against translation, change the scale, rotation, and reflection.

Moment invariant extracted further serve as input in the identification of the algorithm. The process of identification is done to identify the types of human movement based on the input in the form of seven values of moment invariant which had previously been extracted. The final step is to do the identification process using Artificial Neural Network algorithm. The 3 Method: Back Propagation Neural Network), Radial Based Function Neural Network, and K Means Clustering.

B. Procedure and Stage

- **Acquisition of motion of the human body Using Real Data:** This research uses data on real (primary data), the object is currently in the process of human gestures form the human shoulder motion. However, in the early stages of the recently conducted for the motion based on anatomical body position based on frontal/coronal field process motion does not use a special room, however the quality of the camera that was used when the acquisition has a good resolution. Similarly, with a fairly good light for data retrieval of motion. In the study room of the retrieval of the object taken in human body motion space physiotherapist. The process of image acquisition for the early stages of a new do on the direction of the position of objects in motion are conducting human in anatomical position of the body based on the field, coronal or frontal. In the early stages of testing the number of frames the image already extracted produces frames in 1444 frame for 1 video and 28880 Frames for 20 Videos capture processing time when making a motion for 48 seconds.

The body position from a distance of 2.5 meters. The acquisition process is done by the process of the taking of the background next do the motion capture process with a few action motion based on anatomical body position based on frontal or coronal.

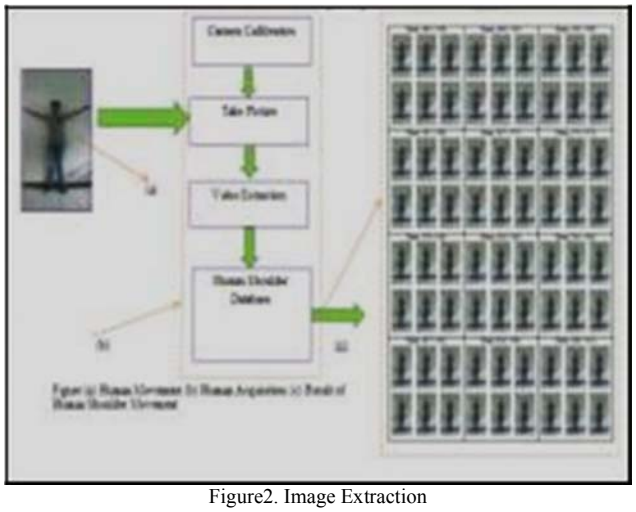

Figure2. Image Extraction

In figure 2, the next stage of image segmentation, extraction of characteristics, and the process of identification of the type of motion based on Range of Motion from the side of the frontal or coronal planes.

- **Image Segmentation:** Segmentation stage on this research is a very important stage to get the silhouette. That is in the form of a motion based on the anatomical position of the body based on the field, coronal or frontal. Stage in the process of segmentation consists of the stages of the process and the creation of Pre-recorded silhouette. Each process is explained in full below:

- **Pre-production Stage:** The stages are performed on this process can be seen in Figure3. Preproduction are grayscale current frame, and background subtraction.

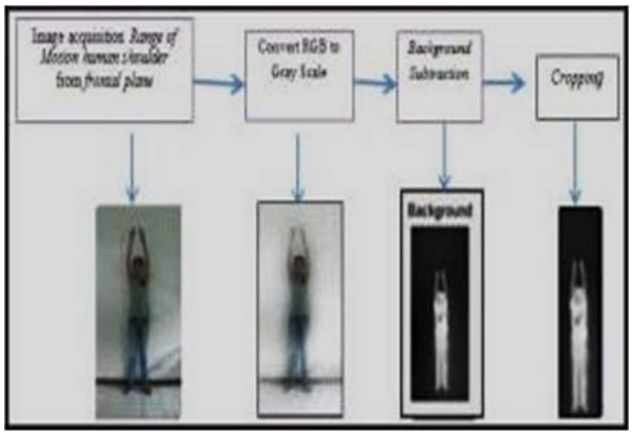

Figure 3 pre-production stage

From figure 3, stages of pre-production process is done through the acquisition process of the Range of Motion on human shoulder in the frontal field divides the body into anterior and posterior, then carried out the process of with the aim of gray scale produces a gray image every pixel contains information only the intensity of the colors white and black, followed by the stages background subtraction. The purpose of the background subtraction is a separate object and background so that the motion of objects can be detected with a clear and appropriate. The last stage is the process cropping obtained after the background subtraction with the purpose the processing the image object only on certain parts the Region of Interest and the results cropping is stored for use on stage Next.

[Pre Process Stages]
Input: motion image acquisition
Output: the results of cropping
Process:
1. Read the anatomical body motion image acquisition on the frontal field/coronal.
2. Perform image color space conversion.
3. Identify the image color space with background subtraction.
4. Store the results of cropping.

- **Grayscale Stage:** The stage is performed to convert the original image RGB the equation used perform the conversion process into grayscale image can be seen in equation (3.1), and the image of the results of the process of grayscale.

$$\text{Grayscale} = 0.2989 * \text{R} + 0.5870 * \text{G} + 0.1140 * \text{B} \quad (3.1)$$

Algorithm Grayscale Stages:
Input: RGB Results
Output: Grayscale

Process:
1. Read the RGB image.
2. The conversion of RGB to grayscale image.
3. Save results of grayscale.

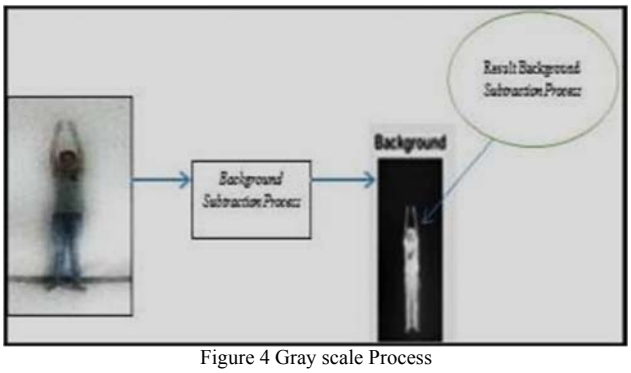

Figure 4 Gray scale Process

From figure 4, stages of the process grayscale is part of the initial process pre next stages being performed to generate the value of the gray with how to perform image color space conversion process which was originally located on the color space RGB (Red, Green and Blue) be grayscale against the selected frame. Process grayscale on the image processing done to simplify the model objects in an image, in the image of no more color, that there is a degree of gray scale, to change the process used the process of converting RGB spaces (Red, Green and Blue) using Equation 3.1. The RGB image is the image of the intensity of the pixel is composed by three colors red, green and blue, while the grayscale value of the intensity of the image is pixel based on grayscale, to ease the process of object in the image.

- **Background Subtraction Stage:** Background subtraction or a foreground detection is one of the techniques in digital image processing and computer vision to do the process or the process of detecting an image detection or take a foreground of the appropriate background based on anatomical body position motion objects based on field, frontal/coronal). Background Subtraction one of important stages of output from background subtraction usually input which will be processed at a rate that is more like a motion object that can be identification. The purpose of using background subtraction is to generate a sequence of frames from video and detect the entire foreground object. The equations used in the process of reduction of the background is done by subtracting each pixel of the frame image of the background with the image motion of the human body, where P [F (t)] is the image of the results of the subtraction, P [I (t)] image background, P [B] the image of the anatomical position of the body in motion body (based on the coronal/frontal). The equation can be written as an equation (3.2) as follows:

$$P[F(t)] = P[I(t)]-P[B] \quad (3.2)$$

The result of the process of background subtraction can be seen in Figure 5.

Algorithm [Stages Background Subtraction]
Input: Results of Grayscale
Output: Background Subtraction

Process:

1. Read the results of Grayscale
2. Do the process
P [F (t)] = P [I t)]-P [B]
3. Store the results of Background Subtraction.

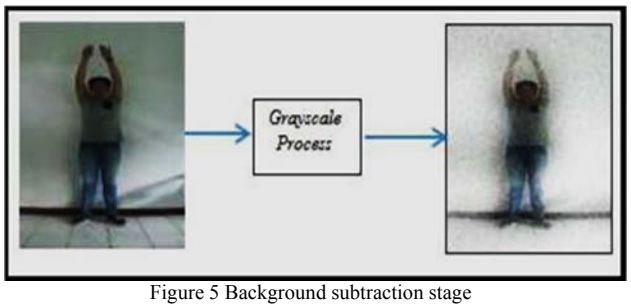

Figure 5 Background subtraction stage

From figure 5, stage background subtraction from the gray scale process to background subtraction with the syntax in the equation 3.2. the stages is carried out from the process of with grayscale conversion process image color space that used to be on color space RGB (Red, Green and Blue) to the selected frame against a grayscale, then the background subtraction process done. Background subtraction or a foreground detection is one of the techniques in digital image processing and computer vision to do the process or the process of detecting an image for detect or take a foreground of the appropriate background based on human shoulder motion objects on the field, frontal. Background Subtraction one important stages the process of image processing. Output the background subtraction usually input which will be processed at a rate that is more like the motion of objects can be identification. The purpose of using background subtraction is to generate a sequence of frames from video and detect the entire foreground object.

- ***Cropping Stage:*** The process of cropping is used to minimize the size of the resulting image, seen in Figure 6.

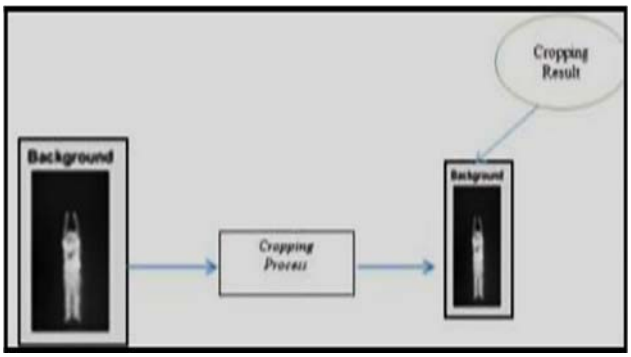

Figure 6 Cropping Process

The result of process of cropping is done after the stages background subtraction, the process of cropping is needed on the process of image processing to get the objects that correspond to the needs, the process cropping obtained after the process background subtraction with the purpose the processing of the image object only on certain parts the Region of Interest (ROI), and cropping are stored for use at a later stage.

- **Silhouette Stage:** Stages in silhouette stage, is the process of conversion of binary image of the stages with threshold, perform the operation of binary image against morphology form filling holes and areas closing to eliminate noise and the segmentation results. The process performed on the stages of silhouettes can be explained in Figure 7.

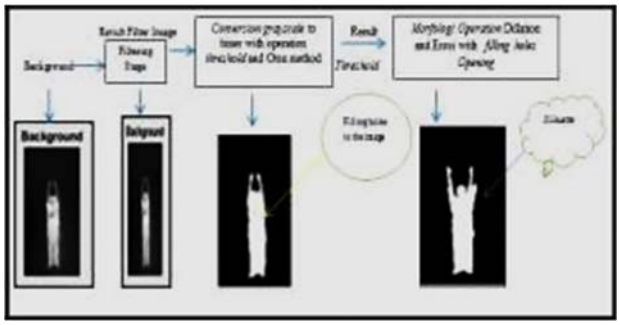

Figure 7 Stages of Silhouette

In figure 7 are stages silhouette of the previous process, namely the process of background subtraction as data input, then conducted the process or filter stage which then convert grayscale image into binary image. A binary image is an image that has only two intensity values the values 0 as black and white as the color value of 1. Binary image used on this research by reason of its small memory usage and to the process of identifying the presence of an object in an image can be represented as a region in the areas of the image are used. The last stage in this process is to perform operations using mathematical morphology dilation and erosion operation.

Algorithm [Stages Silhouette]
Input: Results of Background Subtraction
Output: Silhouette

Process:

1. Read the results of Background Subtraction
2. Filtering Process
3. The conversion process of binary Image with threshold
4. Mathematical Morphology operations
5. Save Results: Silhouette

- **Filtering Stage:** The process of filtering is used to eliminate noise on image processing background subtraction process stages after, noise on the image processing results background subtraction. The result of the filtering process stages can be seen in Figure 8.

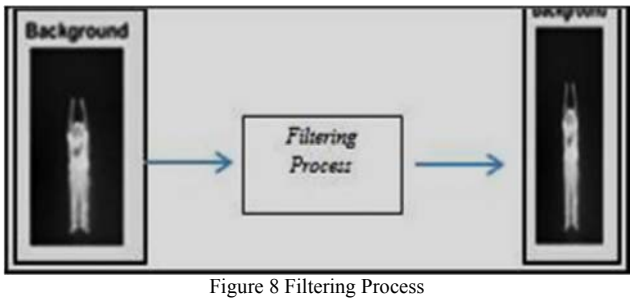

Figure 8 Filtering Process

In figure 8 is the results of the process stages of filtering that is done from the process background subtraction Process filtering are used to perform the process of removing noise on image processing.

- **Stages of the Conversion of binary Image with Threshold:** After the stages background subtraction is formed, the next stage is to do a binary image conversion process with threshold with a given input image background subtraction result is by using the equation (3.3) as follows:

$$g(x,y) = \begin{cases} 1 \, jika \, f(x,y) \geq T \\ 0 \, jika \, f(x,y) < T \end{cases} \quad (3.3)$$

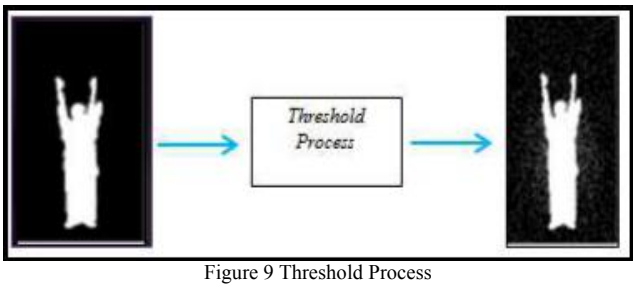

Figure 9 Threshold Process

Equation (3.3) describes the value is binary image threshold result, image is grayscale, and is the value of the threshold. The result of the conversion process of binary image with threshold can be seen on Figure 9. The process

threshold used in this step is the process that had been done after the stages background subtraction. The threshold is a method that is on the image segmentation process can separate the motion of the body's anatomical position (based on the areas of the frontal or coronal) as a foreground with a background that is based on the level of brightness or dark and light levels. The value of the intensity of the image would be worth a dark or black then the intensity value to 0 and the region of an image would be worth a light or white is perfect with a value of intensity is: the results of the conversion process of binary images using threshold was seen on Figure9. The stages background subtraction and filtering. The threshold used in advance determined threshold value. The process of obtaining threshold value do the cutting portion of the image is there, the cutting is done on the part of the background on the image.

- **Morphological Operation stages by Filling Holes:** The next process is to use the morphological operation is operating on binary image operations (black – white) with the aim of changing the structure object in the form of images. Human objects when performing anatomical body position motion (based on the areas of the frontal sagittal and transversal). There are holes or holes present on the human image and can be closed with the morphological operations. In the process produce an image with better results and refined using the operation closing. At this stage the closing operation is the operation of erosion followed by dilation using the same element, the aim of the operation is closing to smooth the contours of the object and removes the whole pixels in areas that are too small to occupied by the element meaning with all foreground structures that are smaller than element by erosion and then smoothing is done through dilation, equations used in the operation of opening is seen at equation (3.4).

$$A \ S = (A \otimes S) \oplus S \qquad (3.4)$$

The results of the conversion process of binary images using the threshold method is seen in Figure 10.

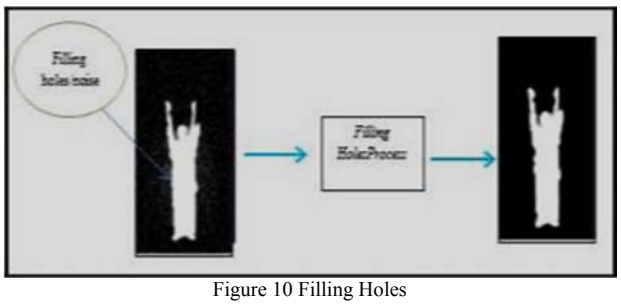

Figure 10 Filling Holes

From figure 10 is the process filling holes for the good result and next step to the skeleton process.

- **Skeleton Stage:** On the process skeleton there are several ways used to skeleton that can be represented for an introduction to the structure of the form the human body which consists the shape of the structure motion based on anatomical body of sagittal, frontal and transversal. In MATLAB, the skeleton can be obtained using function. The result the binary image has been obtains, by using the function. Skeleton an existing image can be processed. Skeleton argument used to produce the display in the form of a skeleton. The process of skeleton can be seen in Figure 11

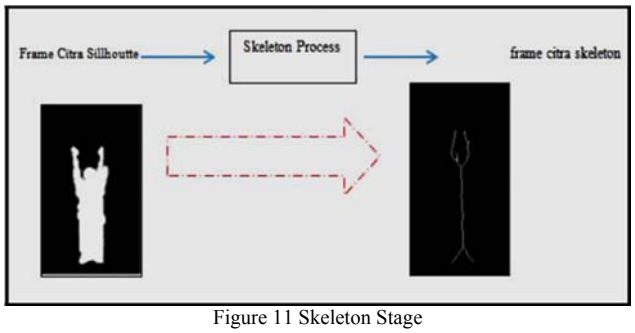

Figure 11 Skeleton Stage

Skeleton model formation stages is generated from operation process morphology the silhouette image so that it produced a model that can be represented for an introduction to the structure the form of the human body in the form of skeleton. At this stage development algorithms for the detection skeleton the human shoulder motion, development stage this system using this type of parameters/variables is different in a detection algorithm skeleton, the variables used is a human shoulder, skeleton that is similar to the shape of the human shoulder motion.

- **Feature Extraction:** Is a technique used to get the existing object from the image that is captured at the time of acquisition process. Feature extraction is a trait or feature of taking a form later on when the value obtained will be analyzed for the next process, feature extraction is done by calculating the number of dots or pixels that are encountered in the process of checking, where checking is carried out in various directions in Cartesian coordinate checking tracing of digital image for analysis.

Algorithm Feature extraction
Input: Skeleton image
Output: Feature Extraction **Process**

```
        1. Read  M
        2.  Calculate moment
    M1=n20+n02;
    M2=(n20-n02)^2+4*n11^2;
    M3=(n30-3*n12)^2+(3*n21-n03)^2;
    M4=(n30+n12)^2+(n21+n03)^2;
    M5=(n30- 3*n21)*(n30+n12)*[(n30+n12)^
    2-3*(n21+n03)^2]+(3*n21- n03)*
    (n21+n03)*[3*(n30+n12)^2-(n21+n03)^2];
    M6=(n20-n02)*[(n30+n12)^2-
    (n21+n03)^2]+4*n11*(n30+n12)*(n21+n
    03
    M7=(3*n21-
    n03)*(n30+n12)*[(n30+n12)^2-3*(n21+n03)^2]-
    (n30+3*n12)*(n21+n03)*[3*(n30+n12)^2-
    (n21+n03)^2];
   3. Show Result moment invariant M1-M7
        M= [M1     M2          M3     M4     M5     M6 M7]
End.
```

Input: Value of the Feature Vector
Output: Moment Invariant [M1-M7]
Process

- **Identification with Artificial Neural Network Algorithm:** invariant feature extraction based on already created and the process of early identification of the human shoulder by specifying several types of motion i.e. object class: class no class object, motion, motion class flexion, extension, the class of motion abduction, adduction motion class, and the type of movement in the field of anatomical are coronal or frontal.

Algorithm 6 [Stages identification of motion]
Trainer: Data input
Output: identification of motion Results
Process
Read data train [train data max , train data min]
Read   moment invariant from skeleton.

For x = 1 to m
For y = 1 to n
Process train data

- **Value of accuracy with *Artificial Neural Network:*** The next stage is to calculate the value of the initial accuracy of motion done using ANN trainer, data was done to recognize the type of human movement based on the input in the form of seven values of moment invariant which had previously been extracted.

IV. RESULTS AND DISCUSSION

A. Data Acquisition

Study on data acquisition process is done using the camera resolution 20MP. The data in the form of videos that contain the movement of the human shoulder joint motion with attention to the scope (Range of Motion).

B. Frame Video Extraction

In this study, total number of frames extracted amounted to 1444 frames for 1 video and 28880 Frames for 20 Videos. On each frame extraction results then do image processing to detect the type of human movement. Here is an algorithm to perform the extraction of video frames into frame 1444 for 1 Video and 28.880 frames for 20 videos.

```
1. Read vid // vid = Video Reader('Video
   1.mp4');
2. If vid Width = Width and if
    Height = .Height;
3. mov =
    truct('cdata',zeros(vidHeight,vidWidt
    h,3,'uint8'),.'color map',[]);
4. // value k = 1;
       while has
     Frame(vid)then   (k).c data = read
 Frame(vid);
5. write(v(k).c (['Frame
    ',num2str(k),'.jpg']))
  k = k+1;
6. end
```

Figure12 Result Extraction Video to Frames

From figure 12 the result of the extraction of frames taken from a video while the process of acquisition and extraction stages are performed against the video, so that the resulting frame from 1 video of 1444 frames and 28.880 frames for 20 videos.

C. Image Processing

Image processing done to the respective frame extraction results in order to identify the types of human movement. Image processing stages are implemented, among others, are: Image segmentation, extraction of characteristics, and identification.

Image Segmentation: Research on image segmentation is carried out using the method of background subtraction for separating a foreground (human) and background (object other than humans). Image segmentation of steps is as follows:

- Set the frame containing the background (background frames) and frame that would like to be detected (current frame).
- Convert the original image color space is RGB color space (Red, Green, Blue) into grayscale perform the operation reduction (subtraction).
- Convert a grayscale image into binary image subtraction results through surgery threshold.
- Perform the operation of binary image morphology form filling holes and areas closing to remove noise and improve the segmentation results.

D. Feature Extraction

After the objects in the image are separated with the background, the further done the stages of extraction characteristics. The extracted characteristics used to differentiate types of movement between one object with another object. Study on the extraction of characteristics is done through the analysis of the morphology based on invariant moment value seven. These values are extracted from each image to differentiate the value classes can be identified that will output the result. The feature extraction process used is the extraction of features with invariant moment with unaffected against geometric transformation (translation, rotation and scaling) in figure14 is the result of the extraction of characteristic shapes that can be made as a result of input from the skeleton and can be done learning outcome is the process of identification of the human shoulder motion in accordance with the standard ROM (Range of Motion).

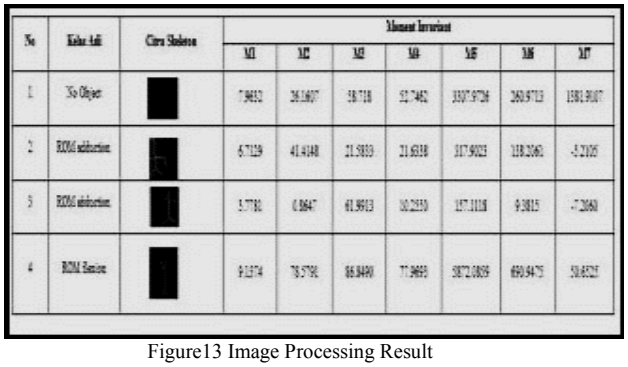

Figure13 Image Processing Result

From figure 13 is an example of the moment invariant feature extraction results extraction process used is the feature extraction of features with invariant moment with unaffected against geometric transformation (translation, rotation and scaling). The values obtained can be used as a reference to determine the process patterns using neural network learning (Artificial Neural Network), so can be generated based on the standard human shoulder motion Range of Motion that consists of class no class object, motion flexion, abduction, adduction, and other classes in accordance with the standard Range of Motion.

E. Simulation and Data Train with Neural Network

This research was conducted to produce identification process of motion human shoulder

Using three algorithms: Back Propagation Neural Network, Radial Based Function Neural Network and K Means Clustering. The process of identification of human motion based on the standard shoulder Range of Motion in the form of motion: Flexion, abduction and adduction. The following processes are performed of each algorithm.

E1. The Training Process Using Back Propagation Neural Network

Neural network training process is done with a variation of the number of neurons in hidden layer the results obtained are shown in Table 1.

Table 1 Architectures that provide the highest accuracy is architecture with the number of 100 neurons in the hidden layer. The architecture is then used to creep towards the output value of the input value on the process of implementation of the system into the look of the user interface. By using the Back Propagation Neural Network algorithms for calculating the accuracy of test data and data training based on the movement of the Range of Motion, then the results obtained can form characteristic of skeleton in accordance with results that have been presented, generate a skeleton model in accordance with the movement, the algorithms used are suitable in accordance with the characteristics of the input data from the results of the extraction of features, value of 1000 simulated training

that epoch, epoch value but at 450 already produce optimal accuracy 97.8517%.

E2. The Training Process Using Radial Based Function Neural Network

By using various algorithms Radial Based Function Neural Network for calculating the accuracy of test data and data training based on the movement of the Range of Motion, then the results obtained can form characteristic of skeleton in accordance with results that have been is displayed, resulting in a model skeleton which corresponds to the movement, the algorithms used are suitable in accordance with the characteristics of the input data from the results of the extraction of features, value of 1000 simulated training that epoch, the value of accuracy obtained of 94.2481% with the value error: 5,719 and value of Mean Square Error for: 0.301596.

TABLE 1 SIMULATION WITH BPNN

	neuron			**accurate**
Layer		**Layer**	**epoch**	
	Hidden layer			**(%)**
Input		**output**		
7	10	1	718	97.5745
7	20	1	1000	97.6517
7	30	1	963	97.4061
7	40	1	730	97.3368
7	50	1	623	97.3368
7	70	1	595	97.4987
7	70	1	565	97.5975
7	80	1	543	97.6754
7	90	1	498	97.7675
7	100	1	450	97.8517
7	110	1	274	97.2675
7	120	1	255	97.2675
7	130	1	236	97.1289
7	140	1	254	97.1289
7	150	1	201	97.2675

E3. The Training Process Using K Means Clustering

Based on the type of data that has been obtained from the process of extraction characteristics have been obtained using invariant moment, then the next stage in the process of training data to get the value of accuracy using neural networks K Means Clustering. Using algorithms K Means Clustering for calculating the accuracy of test data and data training based on the movement of the Range of Motion, then the results obtained can form characteristic of skeleton in accordance with results that have been presented, resulting in a model skeleton lacking accordance with movement, and algorithms that are used less in accordance with the characteristics of the input data from the results of the extraction of features, value of 1000 simulated training that epoch, the value of accuracy obtained 36.0360% of with the value error: 63,964%.

V. CONCLUSION

Identification of the motion range in the frontal or coronal planes begins with the development of algorithms for the acquisition of motion for the human shoulder. We used speed cameras at 30 frames/second in real time video and converted the motion to become multiple frame images of the shoulder. The second stage of the process consisted of image processing. The third phase was the development of algorithms using skeleton models to generate a skeleton of the shoulder. The fourth stage developed feature extraction algorithm using invariant moment that can recognize the special characteristics of the objects in the image without translation, rotation or scaling, and resulted in the extraction of features used to process the training data that are used as input data. The last stage of identifying the type of the standard ROM movement used Artificial Neural Networks.

Moment invariant can be used to identify the human shoulder to extract the objects motion based on its Range Of Motion. Artificial Neural Network learning mechanisms were devised and implemented which were able to complete a number of calculation processes during the learning process using system information processing characteristics similar to human nerve tissues. Three algorithms were used in the process of identifying the human shoulder based on the standard Range of Motion: Back Propagation Neural Network (BPNN), Radial Basis Function Neural Network (RBFNN) and K Means Clustering algorithm.

The results showed that of the 3 algorithms the Back Propagation Neural Network gave the best accuracy at 98%. The Radial Basis Function Neural Network gave an accuracy of 94% and the K Means Clustering 36%.

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