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Article *in* International Journal of Advanced Trends in Computer Science and Engineering · December 2019

DOI: 10.30534/ijatcse/2019/85862019

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8 PUBLICATIONS **87** CITATIONS

ISSN 2278-3091
Volume 8, No.6, November – December 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse85862019.pdf
https://doi.org/10.30534/ijatcse/2019/85862019

Gesture Recognition of Dance using Chain Code and Hidden Markov Model

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ABSTRACT

Dance one culture consists of motion. This paper seeks to recognize Golek Menak Dance movement to be easily studied from Indonesia, where the dance of the dancers (actor) is performed by using the motion capture Kinect sensor which then produces motion data format with Biovision Hierarchy (BVH), where data is a tensor which has position x, y, z. This research use test data Jogetan and Sabetan movement carried out featuring by Chain Code 15 (CC-15), which is a combination of 15 directions with forward motion (1), backward (-1) and fixed (0) to obtain vector quantization which is then carried by the gesture recognition using Hidden Markov Model (HMM). The novelty in this paper use Chain Code 15 (CC-15) to conduct the introduction featuring Dance with HMM classification, which produced an accuracy of 90% of ten (10) test data movement.

Keywords: dance, featuring, chain code, gesture, HMM

1. INTRODUCTION

Dance is a movement class that very wide-ranging in many different styles and has many peculiarities [1]. Given this time, there are still many people who do not understand the kind of dance moves both classical dance and traditional and the meaning of each dance so it takes study on the introduction of the type of attitude dance movement that can be used for research in other fields, learning and assessment [2-4] and preserving the art and culture of Indonesian assets. Research on gesture recognition dance receive more attention worldwide [4] and have a huge impact on our daily lives [5]. However, the amount of research on the introduction of the type of dance is still very limited. Introduction of the type of dance that has been recognized in many previous studies, among others: the classical dance of Indians [6], traditional dance Kazakh [5], traditional dance Greek [1], dance Bharatanatyam [6] and dance [7].

The introduction of the practice of dance movement is an expression meaning the dancer from the dance movements of different attitudes [4]. Each type of dance characterized by the most prominent or emphasis on the movement of body parts such as the motion of the hand, facial expressions, movements of the body and head [6] and head [5]. Golek Menak dance is a form of transformation of a puppet Menak show. Where Menak puppet is a puppet show that uses Serat Menak as a source of stories [8]. Then the Sultan Hamengku Buwono IX combines puppet performances with classical Javanese dance which was then named Beksa Golek Menak or Menak dance [9].

Purpose of this research is for detecting and recognizing the type of dance in Golek Menak dances. Where the Golek Menak dances are generally divided into three parts: Maju Gending (opener), Enjer (middle there is a conversation between a dancer), and closing (cover) as seen in Figure 1 and Figure 2.

Figure 1: Jogetan Gesture

Figure 2: Sabetan Gesture

In every part of the dance has the kind of attitude different motion. Type attitude gesture of Golek Menak dance includes sabetan, jogetan, sembahan sila, ulap-ulap, Muryani busana, lampah sekar, pencak silat and peperangan. This paper uses

two types of motion as sabetan and jogetan will be recognized (Figure 1 and Figure 2).

2. RELATED WORK

The beginning of the research process, beginning with the arrest of the attitude of dance that exists in the Golek Menak dance using Kinect camera. Motion capture results in the form of data and position skeleton motion of the dancers. The number of components of a tensor is 3^n, with n states the tensor range. Data Golek Menak dance from result motion capture with a Kinect sensor already has a data tensor (x, y, z). Tensor data is data that has three or more point coordinates (ie coordinates x, y, z).

Kinect cameras are often used to capture human motion [10] and dance [1],[4],[5],[11]. Camera Kinect been affordable (less than $ 150) and is very practical [10]. Introduction and classification of the type of attitude Golek Menak dance through two stages: 1) the feature extraction using Chain Code 15, and 2) the classification of dance using Hidden Markov Models (HMM). The combination of the two phases is expected to generate motion recognition and classification of the type of attitude and jogetan flick motion with high accuracy.

Research on the dance gesture recognition is a special case of the introduction of human movement in general. Therefore, many researchers are using methods and techniques vary. One input device is the Kinect motion capture [12]. Kinect is an input device for detecting the movement produced by Microsoft [13]. Kinect has an RGB camera facility [14] and the sensor depth (depth sensors). Excess Kinect compared to other devices that are able to capture and track the movement or actions of 3D objects accurately [14], the price of Kinect quite affordable (low cost) [10], resistant to disturbances (non-intrusive) and can work even if the lighting is less [14]. But the Kinect motion capture systems require calibration distance fishing right object [15-16]. In this study, using the Kinect camera calibration range of about 1.5 to 2 m without a marker. Kinect normally generates data skeleton consisting of 20 joints [5],[14]. In this study used data skeleton consisting of 18 joints. Kinect gives detailed information on the parts of the body, particularly the hands and feet including.

At this stage of classification, in general, researchers can use a variety of methods of K-Means [5], Neural Network [17],[18], Bayes Network [10], Hidden Markov Model [5], Support Vector Machine or SVM [11],[14] Fuzzy [19], KNN [2],[7], and approaches Other. In this study, using Chain Code 15 for feature extraction and Hidden Markov Model to conduct the process of classification and recognition Golek Menak dance. Some previous researchers using Hidden Markov [5]. The method HMM for gesture recognition Kazakh dance movement, based on the research results obtained by the recognition rate of 90.82%. The method HMM and 3D chain code (27 direction) to recognize fighting motion result 85 % [20].

Researchers used Chain Code 15 and HMM to classify and identify the kind of attitude on the grounds of data dance skeleton dance movement in the form of time series and the introduction of dance requires a method that can detect in all directions.

2.1 Tensor

Tensor basically is a common form of scalar and vector, where the scalar is a tensor with rank zero (n = 0), the vector is a tensor with rank one (n = 1). The properties are also owned by the tensor vector. Tensor has a geometric relationship between the operation vector, scalar in a multidimensional array process [21].

Tensor has range. The range on tensor will show the sum of its components. The number of components of a tensor is 3^n, with n states the tensor range.

2.2 Chain Code 15 (CC-15)

Before performing data classification motion, should perform feature extraction to obtain the characteristics of the object so it can be used for classifier types of dance movements. Feature extraction is to find areas of significant features on the motion data. Feature extraction tends to identify characteristics that can form a good representation of the object so that it can distinguish objects categorized by varying tolerances.

One feature extraction is used, namely the Chain Code. Algorithms chain code is a sequence number that represents the direction of using certain symbols are actually the same as the system of cardinal directions (north, south, east, west). Chain code is widely used in image processing to represent a line, curve or edge boundary of an area. Chain code is used because it saves a lot of memory [22].

Research on the chain code introduced by Herbert Freeman in 1961 [23] was used to represent the digital curve and then Freeman code is a technique widely used by researchers. Freeman code moves along the curve digital or sequential pixel boundaries based on eight connectivity. The direction of each movement is encoded using number scheme {i|i=0,1,2,...,7} that is a multiple angle 45 degrees counter clockwise from the positive x-axis position. Sometimes the code Freeman with 4 codes directions are also used. In this code use number scheme {i|i=0,1,2,3} which is a multiple of 90 degrees counter-clockwise from the positive x-axis position as shown in Figure 3.

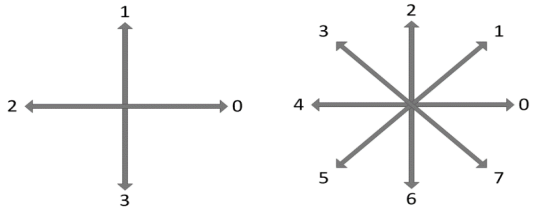

Figure 3: *Chain Code* (Freeman Code)

Freeman chain code both four- and eight-way only able to recognize a two-dimensional object that requires a code that can identify the chain of three-dimensional objects to solve this case. Of this problem, developed a code chain (chain code) number 15 direction as shown in Table 1.

Table 1: Chain Code 15

Chain code	dx	dy	dz	Chain code	dx	dy	dz
1	-1	-1	-1	9	0	0	1
2	-1	-1	0	10	0	1	0
3	-1	0	-1	11	0	1	1
4	-1	0	0	12	1	0	0
5	0	-1	-1	13	1	0	1
6	0	-1	0	14	1	1	0
7	0	0	-1	15	1	1	1
8	0	0	0				

2.3 Hidden Markov Model

Markov chains are usually used to calculate the probability of the order of a state that can be observed. However, there is a sequence that wants to be known but cannot be observed. So to know the sequence, developed a new method that is hidden Markov chains or hidden Markov models (HMM) is a Markov model with the case where the observation is a probabilistic function of the state [24]. Hidden Markov models (HMM) is a stochastic finite automaton learning as well as a specific form of dynamic Bayesian network. HMM consists of two stochastic processes. The first process is a stochastic Markov chain characterized by state and transition probabilities. State on the outer chain is not visible, in other words, hidden. The second stochastic processes produce emissions observations at any time, depending on the probability distribution of state [25].

HMM is obtained by calculating the probability of the sequence of the model results, which the state sequence most likely have produced observations. The formal definition of HMM is as follows:

$$\lambda = (A, B, \pi) \quad (1)$$

$$S = (s_1, s_2, \dots, s_N) \quad (2)$$

$$V = (v_1, v_2, \dots, v_M) \quad (3)$$

S is the set of state alphabet, and V is the set of observations of the alphabet.

$$Q = q_1, q_2, \dots, q_r \quad (4)$$

$$O = o_1. o_2, \dots, o_r \quad (5)$$

Q is defined to be the order of state fixed length L and the corresponding observations O.

$$A = [a_{ij}], a_{ij} = P(q_t = s_j | q_{t-1} = s_i). \quad (6)$$

A is an array of transition, keep the probability of state j i.

$$B = [b_i(k)], b_i(k) = P(x_i = v_k | q_t = s_i). \quad (7)$$

B is an array of observation, keep the probability of observation k produced from j state, and independent t

$$\pi = [\pi_i], \pi_i = P(q_1 = s_i). \quad (8)$$

π are the initials *probability array*

At this stage of classification using Hidden Markov Model (HMM), through two processes of training (training) and testing (evaluation). HMM consists of phi, transition matrices and matrix emissions. Figure 4 is the architectural model by using two-state HMM and eight observation that have phi 2x1, 2x2 transition matrix (state), and 2x8 emission matrix (state × observation).

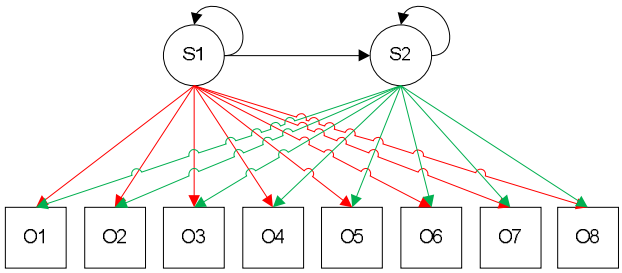

Figure 4: Architecture models HMM

3. METHOD

In this study, using Golek Menak dance as its object. The recording process of motion capture golek Menak dance begins with every kind of dance movements contained in ballet Golek Menak, one by one performed by a dancer. Data is captured dance moves (motion capture) by the Kinect sensor X-Box 360 with a duration ranging capture of 4-6 seconds for each dance movement.

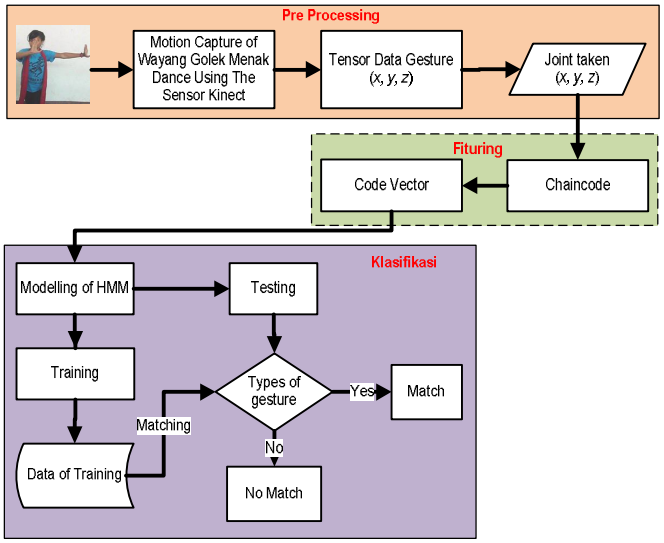

Figure 5: Flowchart recognition and classification Golek Menak dance

The result dance movement has a format Biovision Hierarchy (* .bvh) then processed using software Brekel Kinect V.0.50 aiming to obtain position data of motion (skeleton, bone and joints). Data position tensor of motion is the data consisting of

the coordinates x, y, z which has 61 joint (body points) but only taken 18 major joints. At features, the process will only take a joint dominant. Featuring then performed using Chain Code 15 (CC-15) as the vector quantization to be used for the classification process of dance movements with the HMM method. Flowchart recognition and classification Golek Menak dance can be seen in Figure 5.

4. RESULT AND DISCUSSION

Results of motion capture Golek Menak dance obtained from Kinect sensor form the skeleton motion data is the data tensor x, y, z. Types of Golek dance will be classified which sabetan and jogetan movement. Data tensor motion sabetan and jogetan each consisting of 61 joint, which of 61 the joint is to process data cleaning or cleaning the data for the purpose of disposing of data that is incomplete (missing value) in order to obtain joint-joint major with the number 18 joint. Section 18 of the joint, among others: *Hips, Left up leg, Left leg, Left foot, Right up leg, Right leg, Left arm, Left forearm, Left hand, Right foot, Spine, Left shoulder, Right arm, Right forearm, Right hand, Right shoulder, Neck* and*Head*.

BVH skeleton structure in the form of dots and solid line which shows a process of the movement of the bones and joints of the body. At each dance, the movement has a joint-joint dominant or stand, where the joint is a difference between dance movements with one another. Based on the results arrest Golek Menak dance movements, data recording dance movement that lasted four to six seconds and has a 140 up to 200 *frames*.

In this study, using sabetan and jogetan gesture. Tensor data *x, y, z* of each type of dance moves further taken a joint dominant featuring to do. Joint took in this study on the position of the left hand with different frames as shown in Table 2.

Table 2: Tensor Data of Sabetan and Jogetan Gestures

Frame	Sabetan1			Jogetan1		
	X	Y	Z	X	Y	Z
1	-163,285	100,5776	-648,95	-155,214	74,29397	-658,258
2	-163,361	100,6509	-648,913	-155,214	74,29397	-658,258
3	-163,361	100,6509	-648,913	-154,811	74,27061	-658,118
4	-163,361	100,6509	-648,913	-154,813	74,23198	-658,094
5	-163,361	100,6509	-648,913	-154,813	74,23198	-658,094
	.....up to 181 frames.....			.....up to 149 frames.....		

Next calculate the difference between the frame numbers for *dx*, *dy*, *dz* based axis *x*, *y*, *z*.

Data differentiation results in *dx, dy* dan *dz* obtained then calculating signum against *dx, dy, dz* thus obtained combination -1, 0, +1. Having obtained the data signum then performed the conversion into Chain Code 15 (CC-15). Chain Code 15 (CC-15), which is a combination of 15 directions with forwarding motion (1), backward (-1) and fixed (0). From the results of this dance motion vector code and generate graphs chain code sabetan and jogetan presented in Figure 6 and 7. Furthermore, the classification process using Hidden Markov Models (HMM).

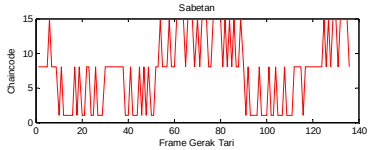

Figure 6: Graph Chain code Motion Sabetan

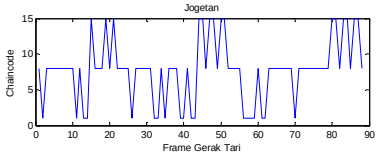

Figure 7: Graph Chain code Motion Jogetan

At the stage of recognition and classification of motion Golek Menak dances using Hidden Markov Model (HMM), through two processes of training and testing. HMM consists of phi, transition matrices and matrix emissions. In the model of dance moves using the chain code 15 using the architecture model HMM with two states and fifteen observations that have phi 2x1, 2x2 matrices which transition (state), and the emission matrix 2x15 (state × observation) for 2-state (Figure 8).

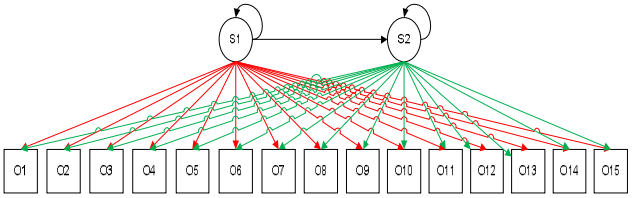

Figure 8: Architectural model HMM with 2 states and 15 observation

Further testing for some of the data movement sabetan and jogetan dance. The following table is the result of testing recapitulation dance moves using the Chain code-15 (CC-15) and HMM.

Table 3: The test results recognition and classification of dance

No	Testing of Motion Data	Result of Testing	Description
1	jogetan1.bvh	Jogetan	Match
2	sabetan1.bvh	Sabetan	Match
3	jogetan3.bvh	Jogetan	Match
4	jogetan2.bvh	Jogetan	Match
5	sabetan2.bvh	Sabetan	Match
6	**jogetan4.bvh**	**Sabetan**	**Not Match**
7	sabetan3.bvh	Sabetan	Match
8	Jogetan5.bvh	Jogetan	Match
9	Sabetan4.bvh	Sabetan	Match
10	Sabetan5..bvh	Sabetan	Match

Based on the test results in Table 3, the nine data odd dance ten kinds of dance movement data successfully identified with the level of recognition accuracy dance movement by 90%.

5. CONCLUSION

Based on the results of testing the classification of types of Golek Menak Dance using Chain Code 15 (CC-15) and Hidden Markov Model, nine motion data dance from ten kinds of motion data been identified with the level of recognition accuracy dance movement by 90%, Novelty in

this study is the discovery method Chain Code 15 (CC-15) as a vector quantization can be used for the classification process using HMM. Another advantage of this method, which is only using a single motion data for each dance movement can be used to recognize dance well.

ACKNOWLEDGEMENT

The author would like to thank the Biocore Laboratory of the Faculty of Information and Communication Technology (FTMK), Universiti Teknikal Malaysia Melaka for the support of its facilities.

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