Thai Journal of **Math**ematics
Volume 19 Number 3 (2021)
Pages 957–963

http://thaijmath.in.cmu.ac.th

ISSN 1686-0209

Fractal Dimension on the Difference of Thai Dance Gestures using Time Series Movement

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Abstract Thai dance gesture is a graceful and interpretative performance. It is closely intertwined with the beliefs, traditions and customs of Thailand and is therefore important to the lives of the people. This research aims to study the fractal dimension on the standard Thai dance gestures using the variation method of time series data. The MPO6050 gyroscope sensor with Arduino is put on the right wrist for considering and analyzing the data of Thai dance gestures on the standard Thai dance. This research is interested in ten standard Thai dance gestures that are different rhythms. The results show that the fractal dimension of the Thai dance gestures in the slow rhythm is lower than the fast rhythm. In conclusion, the fractal dimension is an effective analysis for separating the standard Thai dance gestures in the different rhythms.

MSC: 28A80; 62J02; 00A66
Keywords: Fractal Dimension, Thai Dance Gestures, Variation Method

Submission date: 23.04.2021 / Acceptance date: 10.07.2021

1. Introduction

Standard Thai dance is a movement used all organ of the body and it starts to show of Thai Dramatic Arts. The used songs are delicacy, sweet, stimulating, fun consists of ten songs that demonstrate the uniqueness of Thailand because the songs have lyrics in Thai language. The performers respect to Thai style before performing so they are popular with foreigners. The Thai entertainment uniqueness is both men and women dance in pairs using the structure of song and gesture. The performers cannot change the gesture while dancing with the standard Thai dance. According to the course of the undergraduate student, Thai education management of the undergraduate level added the standard Thai dance gesture. The authenticity of the dance is verified by the observation

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Published by The Mathematical Association of Thailand.

of experts. A study on creating of a tool for validating the accuracy of the dance is interesting. This research studies the classification of Thai dance gesture in the standard Thai dance song considering the movement using the MPU6050 gyroscope sensor. The sensor is put on the right back wrist of the man performer for recording the data with the time series. The data is collected 6 parameters from the sensor. The fractal dimension is used for analyzing the parameter data. Liang [11] compared the methods of the fractal dimension. It was found that the variation method is better than other methods as for linear fitting trend of ruler scale and measure. Therefore, this research aims to study the variation method for approximate the fractal dimension and to select the optimal parameter from the sensor that can classify the Thai dance gesture from the standard Thai dance song.

2. Theory

2.1. Standard Thai Dance

Thai dance known as Ram-Wong is a performance evolved from Ramthone. It is the dancing and singing folklore where both men and women dance in pairs with a thone as a rhythmic instrument. The style of dancing and singing is according to aptitude and no pattern focused on having fun. In 1944, the government of Thailand recognized the importance of national entertainment and saw that there were very popular with tonal dance. Then, the government assigned the Fine Arts Department to improve the new dance as a standard with lyrics, melody and dance from the original to formulate a specific dance for each song in a pattern [2, 3]. The standard dance called standard Thai dance gesture is a performance that is a dance common among women-men as partners by moving around a circle and sang a song composed a new one. Ten songs of the standard Thai dance are shown in Table 1. The Fine Arts Department composed the lyrics of 4 songs as Ngam Saeng Deuan, Chaw Thai, Ram Ma Si Ma Ram and Keun Deuan Ngai. Mrs. Pibulsongkram composed 6 more songs which are Duang Jan Wan Pen, Dok Mai Kong Chat, Ying Thai Jai Ngam, Duang Jan Kwan Fah, Yod Shy Jai Han and Boo Cha Nak Rop. These melodies were composed by the Fine Arts Department and the Public Relations Department.

2.2. Fractal Dimension

An index for characterizing the fractal patterns or sets by quantifying their complexity as a ratio of the change in detail to the change in scale is a fraction dimension. It is mathematical concept relied on the method of finding geometric fractions [9]. The general shape of the object is repeated at arbitrarily smaller and smaller scales which exhibit self-similarity. The true fractals repeat the detail to an infinitely small scale such as in nature are self-similar up to some finite limit. The fractal analysis provides a unique insight into a wide range of natural phenomena as turbulence[9], river networks [12], urban growth [5], human physiology [6, 7], medicine [4] and market trends [8]. The theoretical fractal dimension for sets describing the ordinary geometric shapes is points (0-dimension), lines (1-dimension), surfaces (2-dimension) and volumes (3-dimension) [9]. The concept of a geometrical dimension is generalized by examining the scaling behavior of such trivially

TABLE 1. Songs of standard Thai dance and their Thai dance gesture

.5Song	Standard Thai dance gesture	
	Man	**Woman**
1. Ngam Saeng Deuan (NSD)	Sod Soi Mala	Sod Soi Mala
2. Chaw Thai (CT)	Chak Paeng Pad Na	Chak Paeng Pad Na
3. Ram Ma Si Ma Ram (RMSMR)	Ram Sai	Ram Sai
4. Keun Deuan Ngai (KDN)	Sod Soi Mala Plaeng	Sod Soi Mala Plaeng
5. Duang Jan Wan Pen (DJWP)	Kaek Tao Kao Rang Pala Piang Lai	Kaek Tao Kao Rang Pala Piang Lai
6. Dok Mai Kong Chat (DMKC)	Ram You	Ram You
7. Ying Thai Jai Ngam (YTJN)	Prom Si Na, Yoong Fon Hang	Prom Si Na, Yoong Fon Hang
8. Duang Jan Kwan Fah (DJKF)	Chang Prasan Nga, Chan Song Khod Plaeng	Chang Prasan Nga, Chan Song Khod Plaeng
9. Yod Shy Jai Han (YSJH)	Jor Plerng Gan	Chanee Rai Mai
10. Boo Cha Nak Rop (BCNR)	Chan Song Khod, Kor Gaew	Kad Jang Nang, Lor Gaew

self-similar objects as a line, a square, and a cube. A power law relation between the number of pieces (N) and the reduction factor (R) calculated as

$$N = \frac{1}{R^D} \tag{2.1}$$

or

$$D = \frac{\log N}{\log (1/R)} \tag{2.2}$$

where D is the self-similarity dimension.

There are many methods for estimation the fractal dimension. Table 2 shows the comparison of the method based on the fractional Brownian motion curve for estimation the fractal dimension. It is found that there is the smallest error of estimation the fractal dimension in the variation method. Then, this research is interested in this method for assigning the fractal dimension to time series.

Dubuc [1] showed how to generalize the variation method to higher dimensions. They claimed that the result is a reliable, more robust and efficient algorithm for estimation the fractal dimension of surfaces. The method uses coverings built out of intervals, ϵ. The covering is constructed by determining oscillations at interval points along the curve. For the continuous curve $y = f(x)$, the ϵ-oscillation at a point is simply:

$$v(x_i, \epsilon) = max f(x_i) - min f(x_i) \tag{2.3}$$

TABLE 2. Methods for estimating the fractal dimension

Method	Calculated speed	Estimated error	Source
Box-Counting	Fast	Small	[1]
Rescale Range	Fast	Small	[13]
Higuchi	Medium	Large	[14]
Scaling Properties of Variance	Medium	Large	[15]
Horizontal Structuring Element	Slow	Medium	[1]
Variation	Slow	Smallest	[1]

This interval span, ϵ gives the scale at the measured oscillation. The variation of ϵ is integrated v over the curve, denoted $V(\epsilon)$ as:

$$V(\epsilon) = \int_0^1 v_i(x, \epsilon)dx \tag{2.4}$$

The rate at that area $V(\epsilon)$ decreases as ϵ tends to zero that is calculated to find the fractal dimension. The slope of a log-log plot of $1/\epsilon$ versus $V(\epsilon)/\epsilon^2$ is the fractal dimension.

From $N = \frac{1}{\epsilon^2}V(\epsilon)$ and $R = \epsilon$, therefore the fractal dimension of the variation method is calculated as:

$$D_v = \frac{log(\frac{1}{\epsilon^2}V(\epsilon))}{log\frac{1}{\epsilon}} \tag{2.5}$$

The total area covered by the curve of time series is calculated as:

$$V_v(\epsilon) \approx \frac{1}{N+1}\sum_{i=1}^{N} v(x, \epsilon) \tag{2.6}$$

3. METHODOLOGY

3.1. GYROSCOPE SENSOR

Gyroscope sensor is also called angular rate sensor or angular velocity sensors. This sensor is installed in applications where the orientation of the object is difficult to sense by humans that can measure and maintain the orientation and angular velocity of an object. It is a spinning wheel or disc in which the axis of rotation (spin axis) is free to assume any orientation by itself [10]. According to the conservation of angular momentum, the orientation of this axis is unaffected when rotating by tilting or rotation of the mounting. There are three types of angular rate measurements depended on the direction that consists Yaw- horizontal rotation on the flat surface when seen the object from above, Pitch- Vertical rotation as seen the object from front and Roll- horizontal rotation when seen the object from front. This research uses the MPU6050 gyroscope sensor. It is complete 6-axis Motion Tracking Device including 3-axis accelerometer, and 3-axis gyroscope. The accelerometer is used to detect the angle of tilt or inclination along the X, Y and Z axes. When the accelerometer is placed on the flat surface, it will measure 0g on the X- and Y-axes and +1g on the Z-axis. The full scale range of the digital output can be adjusted to

2g, 4g, 8g, or 16g. The gyroscope is used to detect the rotation velocity along the X, Y, Z axes. When it is rotated about any of the sense axes, the Coriolis effect causes a vibration that is detected by a capacitive pickoff. The resulting signal is amplified, demodulated, and filtered to produce a proportional voltage to the angular rate. This voltage is digitized using individual on-chip 16-bit Analog-to-Digital Converters (ADCs) to sample each axis. The full-scale range of the gyroscope sensor may be digitally programmed to 250, 500, 1000, or 2000 degrees per second. The ADC sample rate is programmable from 8,000 samples per second, down to 3.9 samples per second, and user-selectable low-pass filters enable a wide range of cut-off frequencies. Then, the studied parameters of MPU6050 sensor are the angle of tilt (accelerometer) and rotational velocity (gyroscope) along the X, Y and Z axes denoted as Ax, Ay, Az, Gx, Gy and Gz, respectively.

3.2. Experiment

This research starts from selecting the optimal sensor, MPU6050 gyroscope sensor, that can collect the studied parameters consists the angle of tilt and rotational velocity along the X, Y and Z axes. The next step is to write the code for collection the parameters under Thai dance gesture followed on ten songs of the standard Thai dance as Ngam Saeng Deuan, Chaw Thai, Ram Ma Si Ma Ram, Keun Deuan Ngai, Duang Jan Wan Pen, Dok Mai Kong Chat, Ying Thai Jai Ngam, Duang Jan Kwan Fah, Yod Shy Jai Han and Boo Cha Nak Rop. After that, to put MPU6050 sensor with Arduino is on the right back wrist of man while the man dances. So, the sensor records the data every a half of second. Finally, the research records and analyzes the data of Thai dance gestures using the fractal dimension on the variation method.

4. Result and discussion

The variation method is used to approximate the fractal dimension which is approximated from the slope of log-log plot on linear regression. The fractal dimension is approximated from the parameter of six time series with the ten songs of the standard Thai dance on male is shown in Table 3 and Figure 1. The time series data is formulated from six parameters, the angle of tilt (accelerometer) and rotational velocity (gyroscope) along the X, Y and Z axes denoted as Ax, Ay, Az, Gx, Gy and Gz, respectively, of MPU6050 sensor.

From Table 3, using the scatter plot with x-axis shows ten songs of the standard Thai dance and y-axis shows the value of fractal dimension. The different characteristic line represents the difference of the MPU6050 sensor as shown in Figure 1.

From Figure 1, the third song, Ram Ma Si Ma Ram, is the highest fractal dimension in the standard Thai dance. On the contrary, the forth song, Keun Deuan Ngai, is the lowest fractal dimension in the standard Thai dance. To consider the average of fractal dimension, velocity movement of gesture and rhythms in each song, it is found that the order of song descends starting from Ram Ma Si Ma Ram, Duang Jan Kwan Fah, Ying Thai Jai Ngam, Boo Cha Nak Rop, Duang Jan Wan Pen, Yod Shy Jai Han, Dok Mai Kong Chat, Chaw Thai, Ngam Saeng Deuan to Keun Deuan Ngai. Moreover, to select the optimal parameter is considered from the fractal dimension from six parameters. It is analyzed the difference of fractal dimension between the averaged value and the value of each parameter. The result shows that the order of songs descends starting from Az, Ay, Gx, Ax, Gy to Gz. It is found that Az is highest difference fractal dimension

TABLE 3. Fractal dimension of the ten songs of the standard Thai dance on male

Song	Parameter					
	Ax	**Ay**	**Az**	**Gx**	**Gy**	**Gz**
NSD	1.2559	1.1880	1.0988	1.2696	1.3124	1.3150
CT	1.2432	1.2348	1.1167	1.2571	1.2707	1.3325
RMSMR	1.6228	1.5500	1.6358	1.6118	1.6906	1.5209
KDN	1.1380	1.0292	1.0532	1.0319	1.2032	1.0906
DJWP	1.3837	1.2810	1.4335	1.3766	1.5086	1.3425
DMKC	1.2242	1.2713	1.2192	1.2700	1.3712	1.1703
YTJN	1.4085	1.4720	1.3878	1.4232	1.4351	1.4668
DJKF	1.4793	1.4661	1.4760	1.4684	1.4337	1.5377
YSJH	1.2899	1.2675	1.1198	1.3412	1.1998	1.3423
BCNR	1.4121	1.4496	1.4345	1.4739	1.3351	1.4543

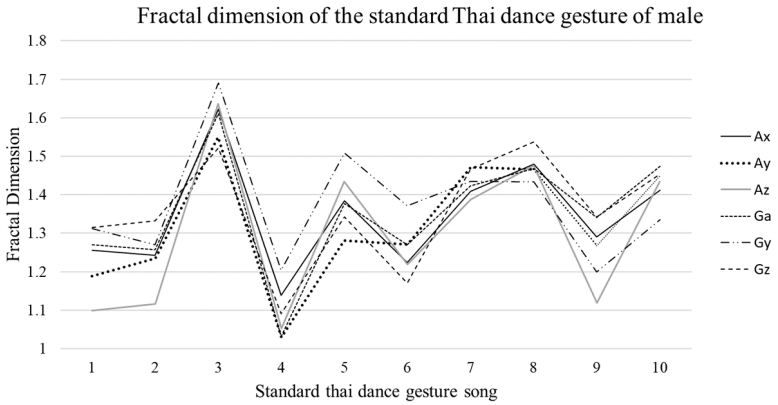

FIGURE 1. Fractal dimension of ten songs of the standard Thai dance of male

of six parameters. Then, angle of tilt along the z axes is the optimal parameter for approximation the fractal dimension of the difference of Thai dance gestures.

5. CONCLUSION

The standard Thai dance is used for the basic teaching and learning in Thailand. It is traditionally rigid and absolute gesture. From the past, to check the correctness of the dance is from observation. So, this research is the starting point for the transformation of analytical accuracy of Thai dance gestures using Mpu6050 gyroscope sensor detected the angle of tilt and rotational velocity along the X, Y, Z axes. The sensor has recorded the parameter with the time series data. This research is conducted to analyze the variables that should be used to determine the authenticity of the dance. The fractal dimension using the variation method is analyzed from ten songs of the standard Thai dance gesture and six parameters of the recorded sensor. The result shows that the angle of tilt along

the z axes is the optimal parameter that is the most different dimension between the averaged value and the value of each parameter. When the data is sorted in descending, it is found that the order of song is same in both of rhythms and gesture velocity.

Acknowledgements

We would like to thank the referees for their comments and suggestions on the manuscript. This work was supported by Chanthaburi Collage of Dramatic Arts and Bunditpatanasilpa Institute.

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