Developing the Evaluation System of the Thai Dance Training Tool

1st Patcharaphon Sribunthankul
Knowledge and Innovation Research Laboratory
College of Arts, Media and Technology, Chiang Mai University (CMU)
Chiang Mai, Thailand
patcharaphon.sri@gmail.com

2nd Pradorn Sureephong
College of Arts, Media and Technology, Chiang Mai University (CMU)
Chiang Mai, Thailand
dorn@camt.info

3rd Karim Tabia
CRIL UMR CNRS 8188
Université d'Artois
Lens, France
tabia@cril.univ-artois.fr

4th Truong-Thanh Ma
CICT, CanTho university
(of Affiliation)
CanTho Vietnam
truongthanh1511@gmail.com

***Abstract*—The Thai traditional dance training tool was created with the objective to develop the technologies for supporting the learning of Thai traditional dance, which still has been transferred orally from generation to generation. The tool collects the dataset of dance movements from traditional Thai dance experts using motion capture system and it uses them to show a demonstration for the user, then it gives the user a stage to perform and record their movement data using the Microsoft Kinect sensor. The movement data obtained will be evaluated and a score is generated to provide feedback for the user at the end. The project also tests the performance of the evaluation by comparing the score generated by the tool with the score generated by a traditional Thai dance teacher from the College of Dramatic Arts to calculate the inverted pair and the displacement in order to see the difference. The project tries to test the evaluation method that uses the formula to calculate the similarity percentage between the user's movement and the expert's movement. This testing method gives 17.7% inverted pair and 53% displacement. The project and also tries many evaluation methods using different regression algorithms in machine learning from which the best results are from the Random Forest Classifier that gives 7.89% inverted pair and 48% displacement, and from the Decision Tree Regressor that gives 15.79% inverted pair and 44% displacement.**

Keywords*— *Thai traditional dance; Microsoft Kinect sensor; evaluation; Thai Dance Training Tool;

I. INTRODUCTION

Thailand is one of the richest cultural heritage countries. Thai tradition and culture, which has grown along with the lifestyle of Thai people for a long time, contribute to the invention of many cultural arts. One of the most valuable ones is Thai Dramatic Art, the dance performance that has played an important role in the history of culture. From rituals to celebrations, it penetrated all the important dimensions of the past.

To preserve this intangible cultural heritage, the government intends to make the new generation familiar with the Thai dance by implementing basic Thai dance lessons into the basic education core curriculum of the Thai education system. Besides, they also established the College of Dramatic Arts which uses a specific curriculum focused on teaching Thai Dramatic Arts, especially for students who are interested in Dramatic Arts and want to make a career in this field. Recently, technology has been introduced to manage the traditional Thai dance knowledge. Y Tongpaeng developed a tool for storing the traditional Thai dance movements. [1] His projects aim to translate Thai dance notation using Labanotation to digital data [2] and convert them into 3D animation to represent it to the user [3]. However, up until now, there are not too many tools or technology provided to support practical learning. Thai dance knowledge is still transferred to the next generation orally because the movement is delicate, complex and has a lot of details. The process of learning starts from watching the demonstration from the teacher to observe how to pose and move, then the students perform them following the demonstration while the teacher thoroughly corrects the students' movements along their performances. Moreover, students also need to regularly practice by themselves to improve their movements more precisely.

In 2012, João presented the prototype of the system called "Super Mirror" for assisting the ballet learners to practice their skills. This system compares the captured live motion with the recorded ballet movements to show the difference and provide real-time instructional feedback for the user [4]. In 2015, S. Chernbumroong proposed a research about Gamification in the classroom, his studies showed that gamification elements can encourage the motivation in learning [5], Based on the ideas of the practical dance learning tool and the gamification tool, we present the development of the Thai dance training tool, the tool for practicing the traditional Thai dance by evaluating the user's movements and giving users the useful feedback. By following the steps of the traditional Thai dance learning, the tool will give users the demonstration in 3d animation which is an appropriate way for learning inputs [6]. Next, the tool will let users perform to evaluate their movements. This paper focuses on developing the evaluation method and improving the evaluation performance to be equivalent to the standard evaluation of the College of Dramatic Arts.

The paper is organized as follows : Section II is the description of the system structure of the tool and the evaluation method using the formula, section III describes the performance testing and the results, section IV describes the experiment of machine learning as an evaluation method and the testing results. Finally, section V contains the conclusions of the experiment results.

II. STATE OF THE ART DANCE TRAINING TOOLS

In 2016, Ob-orm developed a prototype for the Thai dance training tool. The prototype has a function for evaluating the accuracy of a real-time traditional Thai dance movement form

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the user by obtaining the dance movement from the Kinect sensor and then comparing it with the traditional Thai dance movement collected from an expert in the database. The process is to compare the angle of the bones which is composed from the connection of the joints from the 3D models that contain the movements from 2 sources. The prototype calculates an average percentage and grade in the end. [7]

Yootthapong proposed the work titled Evaluating Real-Time Thai Dance Using Thai Dance Training Tool for assisting the traditional Thai dance students by correcting the accuracy of their dance movements. The work uses a similar model to Ob-orm's focusing on designing a system and developing an evaluation method. [8]

Based on Yootthapong's work, this paper continues to develop the evaluation method focusing on improving the performance of the evaluation. Below is a description of the training tool:

A. System Overview

The Thai Dance Training Tool compares the real-time traditional Thai dance movement of the user with the traditional Thai dance expert's movements to evaluate the accuracy of the user's dance movements and to give the user a feedback in the form of similarity percentage. The system diagram of the tool is shown in Figure 1. Traditional Thai dance movement data from the expert is collected using the optical motion capture system. This motion data is applied to the skeleton of the 3D human model and then stored in the form of a 3D animation in the database of the tool to be used in the comparison process as a criteria. The tool is installed on a computer which is connected to a Microsoft Kinect sensor. When the user performs the dance in front of it, the tool can obtain the dance movement from the user. The dance movement from the user is also applied to the skeleton of another model that has the same characteristics as the model that the movements ofthe expert had been applied to, in real-time. The comparison method uses data from the joints ,which are the sub-units of the skeleton that control each body part of the model, to calculate the differences.

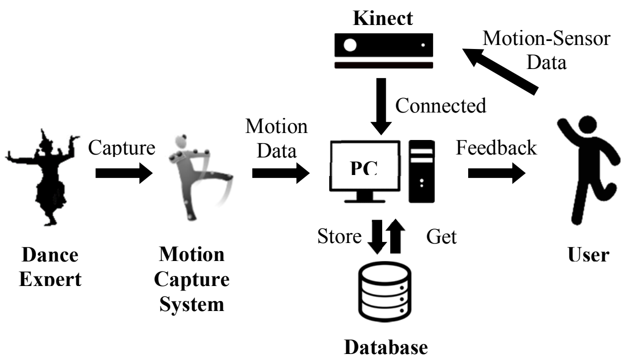

Fig. 1. The system diagram.

B. System Prototype

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- Menu stage - The menu stage offersthe dance choices allowing the user to choose the dance that they want to practice.
- Play stage - After the user selects a dance. After selecting the dance, a video of the dance is shown to let the user know how to move before practicing based on observation. When the video ends, a countdown shows the user how much time he or she has to prepare. The user can start performing immediately when the countdown ends, the screen shows an animation of the user's movements from Kinect and also an animation of the expert's dance beside. In the meantime, the system starts processing the comparison.
- Result stage - This stage gives the user the similarity percentage between the user's dance and the expert's dance to provide feedback on accuracy.

C. Comparison method

As mentioned above, the tool uses data from the joints to compare the movements of the user and the expert.

Jacky C.P. Chan proposed a dance training system using the motion capture. To find the best measurement method for evaluating the dance performance, he made an experiment to compare three different measurement methods including joint position, joint velocity, and joint angle. The result shows that joint position is the best measurement method. The second and the third are angle and velocity, respectively. [9]

The comparison process compares the position data and the rotation data of each joint one by one in every frame, then calculates the result in a form of a similarity percentage.

For the position comparison, the difference is calculated using the Euclidean distance between joints based on the following formula:

$$Distance = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$$

To find the position similarity percentage, the maximum threshold, which is the value for defining the range the user accuracy is measured in, are set in Unity units, then it is used to calculate the percentage as the following formula:

$$Position\ similarity\ percentage = 100 - (\frac{Distance}{Threshold} * 100\ )$$

For the rotation comparison, 3D Unity units provide a function called *Quaternion.Angle*. By using this function, the rotation differences can be obtained as an angle between two rotations in degrees. After that, the rotation similarity percentage is calculated by following the same method as the position accuracy but the threshold would be fixed to 360 degrees.

$$Rotation\ similarity\ percentage = 100 - (\frac{Angle\ between\ two\ rotation}{360} * 100\ )$$

Then the tool calculates the averages of the Position Similarity Percentage and the Rotation Similarity Percentage as a final percentage of each joint.

For the result, the tool provides the similarity percentage between the user's dance and the expert's dance which is the average of the similarity percentages of all joint types.

III. THE EVALUATION METHOD RELEVANT FOR SCORING THE DANCES

In order to get a good performance evaluation system, the evaluation system needs to be able to rate in accordance with the standard scoring from the College of Dramatic Arts. Thus, the result from our comparison method are analyzed along with the score from a traditional Thai dance teacher from the College of Dramatic Arts to see if they are relevant or not.

Ravi Kumar describes the methods for measuring the distance between ranking [10] that could be used to analyze the score to identify the correlation of the scores from a program evaluation and a standard scoring. There are 2 methods that has been chosen for analysis in this work as follows:

A. *Kendall's Tau*

This method provides a total number of inversions which is counted from pairs of elements i and j from the teacher's rank and the tool's rank σ such that $i < j$ and $\sigma(i) > \sigma(j)$ as the following formula:

$$K(\sigma) = \sum_{i>j} 1_{\sigma(i)<\sigma(j)}$$

B. *Spearman's Footrule*

This method gives a total displacement which is calculated from the distance an element i moved due to $\sigma = |i - \sigma(i)|$ as the following formula:

$$F(\sigma) = \sum_{i} |i - \sigma(i)|$$

The dance data is collected from the sample group of people with scores from the tool and scores from the traditional Thai dance teacher. Then the scores from these 2 sources are ranked generating the traditional Thai dance teacher's rank and the tool's to be applied to the measurement method.

The dance data from 20 people were analyzed using the methods that were mentioned above, the result is provided in table I. The score analysis shows that as regards the example gesture the scoring between the tool and the teacher has 33 inverted pairs which is 17.7% of the result, and the total number of displacements are 106 which is 53%. The results show that the scorings don't correlate well.

TABLE I. THE RESULT FROM SCORES ANALYSIS

No.	Score		Rank		K(σ)	F(σ)
	Expert	Computer	Expert	Computer		
1	80	49	3	16	8	13
2	80	50	3	7.5	2	4.5
3	80	49	3	16	8	13
4	80	59	3	1	0	2
5	80	50	3	7.5	2	4.5
6	70	50	6	7.5	2	1.5
7	60	50	7	7.5	2	0.5
8	50	49	12	16	1	4
9	50	49	12	16	1	4
10	50	50	12	7.5	1	4.5
11	50	51	12	3	1	9
12	50	49	12	16	1	4
13	50	50	12	7.5	1	4.5
14	50	50	12	7.5	1	4.5
15	50	50	12	7.5	1	4.5
16	50	49	12	16	1	4
17	40	54	18.5	2	0	16.5
18	40	49	18.5	16	0	2.5
19	40	49	18.5	16	0	2.5
20	40	49	18.5	16	0	2.5
Sum					33	106

IV. MACHINE LEARNING APPROACH FOR DANCE TRAINING SCORING

Since the evaluation system that has been developed can't evaluate as good as expected, the experiment needs to find another method that can provide more relevant results to improve the tool performance. Regression algorithms in machine learning provide a method for such an approach. By putting an amount of dance movement data from the user with the rating from the teacher for each movement data into the tool, the program automatically learns how the teacher rates the scores from the movement-score pairs as inputs, then the program can evaluate the dance based on that dataset.

A. *Dataset Structure*

To teach the machine, the dataset files are prepared as inputs for the learning process, one file for one dance gesture. The files contain lines of data we extract from the dance movement animation files, one line for one case. Each line consists of a user movement data plus expert movement data, which is the position data and the rotation data of each joint from every frame of movement, and ends with a score that the expert gives for the user movement of that line.

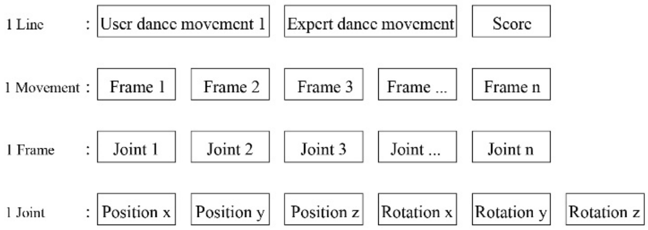

Fig. 2. Dataset Structure

B. *Using Regression Algorithm to Predict The Scores*

We extracted the significant features from our tool including positions and rotations of each joint of body parts.

Particularly, there are six selected features to express each joint (position x, position y, position z, rotation x, rotation y, rotation z). Therefore, we represented one movement data being a feature vector with at least 294360 extracted features. The same 20 movement data of the traditional Thai Dances that we used in the evaluation system in section 3 are used for training and testing. With a large dimension extracted from each movement data and a few items/vectors (20 videos), we use several regression algorithms to predict the score such as SVR (Support Vector Regression), Linear Regression, Lasso, Decision Tree Regression, Decision Tree Classifier for testing using many different parameters.

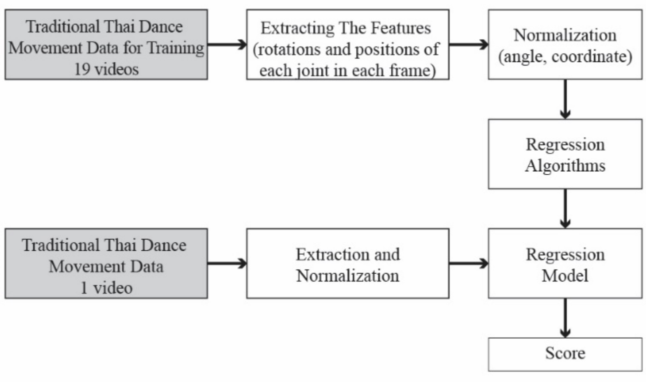

Fig. 3. Regression Framework

For the experiment, we created the leave-one-out training sets, we employed the procedure to create n independent replicates of the original data set where n is the number of the Thai dance videos (n=20 videos). Each set (replicate) is identified by a value i where i = 1, …, n. Individual observations are systematically removed from each of the sets, creating a training set i training and testing set i test. We accomplished this by creating a second id for each movement data based on observation number in the original dataset, then deleting if the second id equals i. These steps simply create the indicator variable for whether the data for a certain individual will be used in that particular training set or as the testing set.

The experimental result is represented in the table below:

TABLE II. SCORE FROM MACHINE LEARNING METHOD

No.	Machine Learning Score										
	Linear Regression	SVR (1)	SVR (2)	SVR (3)	SVR (4)	Lasso	LassoLars	Random Forest Classifier	Decision Tree Regressor	Random Forest Regression (1)	Random Forest Regression (2)
1	58	55	58	57	58	56	70	50	80	63	57
2	62	58	62	61	62	56	56	50	50	48	57
3	64	56	64	63	64	56	52	80	50	67	60
4	52	50	52	52	52	56	59	80	50	57	54
5	61	53	60	60	60	56	49	50	50	61	52
6	63	58	63	63	63	57	65	80	50	62	64
7	56	54	56	57	56	57	59	50	70	64	61
8	39	40	39	41	39	57	56	50	50	50	48
9	53	50	53	53	53	57	59	50	50	50	54
10	54	51	54	54	54	57	48	50	50	56	54
11	60	53	60	59	60	57	57	80	80	66	59
12	70	61	70	69	70	57	63	50	50	56	61
13	64	63	64	64	64	57	63	50	50	64	62
14	62	55	62	61	62	57	55	50	50	59	56
15	62	59	62	61	62	57	71	80	50	56	63
16	57	55	57	57	57	57	58	80	80	58	65
17	62	56	62	62	62	58	63	50	40	59	63
18	56	57	56	57	56	58	60	50	50	61	58
19	46	46	46	47	46	58	67	50	80	58	55
20	47	48	47	48	47	58	52	50	40	58	55

Using the same method as the analysis of the program evaluation, the result from all machine learning algorithms that are used in the experiment is analyzed as shown in the following tables:

TABLE III. INVERTED PAIRS

No.	K(σ) - Inverted Pairs											
		Machine Learning										
	Program Evaluation	Linear Regression	SVR (1)	SVR (2)	SVR (3)	SVR (4)	Lasso	LassoLars	Random Forest Classifier	Decision Tree Regressor	Random Forest Regression (1)	Random Forest Regression (2)
1	8	7	6	7	7	7	15	1	4	0	3	9
2	2	3	3	3	4	3	15	11	4	4	15	9
3	8	1	5	1	2	1	15	13	0	4	0	7
4	0	12	11	12	12	12	15	7	0	4	10	12
5	2	6	9	6	6	6	15	14	4	4	4	14
6	2	2	3	2	2	2	4	2	0	4	3	1
7	2	7	7	7	6	7	4	6	3	3	1	4
8	1	4	4	4	4	4	4	3	0	1	4	4
9	1	2	2	2	2	2	4	3	0	1	4	4
10	1	2	2	2	2	2	4	4	0	1	4	4
11	1	1	2	1	1	1	4	3	0	0	0	1
12	1	0	0	0	0	0	4	1	0	1	4	1
13	1	0	0	0	0	0	4	1	0	1	0	1
14	1	0	2	0	1	0	4	3	0	1	1	2
15	1	0	0	0	1	0	4	0	0	1	4	0
16	1	1	2	1	1	1	4	3	0	0	2	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
Sum	33	48	58	48	51	48	119	75	15	30	59	73

TABLE IV. TOTAL DISPLACEMENT

No.	F(σ) - Total Displacement											
		Machine Learning										
	Program Evaluation	Linear Regression	SVR (1)	SVR (2)	SVR (3)	SVR (4)	Lasso	LassoLars	Random Forest Classifier	Decision Tree Regressor	Random Forest Regression (1)	Random Forest Regression (2)
1	13	8	7	8	9.5	8	15	1	10.5	0.5	2	8.5
2	4.5	3.5	1.5	3.5	4	3.5	15	11.5	10.5	9	17	8.5
3	13	0.5	4.5	0.5	0.5	0.5	15	14.5	0.5	9	2	5
4	2	14	13.5	14	14	14	15	7	0.5	9	11	14
5	4.5	6	10.5	6.5	6	6.5	15	16	10.5	9	4.5	16
6	1.5	2	1.5	2	2.5	2	4	2	2.5	6	0	4
7	0.5	6.5	5	6.5	5.5	6.5	3	3	6.5	2	3.5	0.5
8	4	8	8	8	8	8	2	2.5	1.5	0	6.5	8
9	4	4	4.5	4	4	4	2	2	1.5	0	6.5	5
10	4.5	3	3	3	3	3	2	8	1.5	0	4	5
11	9	2	1.5	2.5	2	2.5	2	1	8.5	9.5	10	3
12	4	11	10	11	11	11	2	6	1.5	0	4	5.5
13	4.5	9.5	11	9.5	10	9.5	2	6	1.5	0	8.5	7
14	4.5	5.5	2	5.5	5	5.5	2	4	1.5	0	2.5	1
15	4.5	5.5	9	5.5	5	5.5	2	11	8.5	0	4	8.5
16	4	0	2	0	0.5	0	2	0	8.5	9.5	0	11
17	16.5	12	11	12	13.5	12	16	12.5	5	1	9	15
18	2.5	5	12.5	5	6	5	16	10.5	5	6.5	11	8.5
19	2.5	0.5	0.5	0.5	0.5	0.5	16	15.5	5	16	6.5	4
20	2.5	0.5	0.5	0.5	0.5	0.5	16	1	5	1	6.5	4
Sum	106	107	119	108	111	108	164	135	96	88	119	142

From the score analysis result, there are 2 algorithms that give the number of inverted pairs and the total displacement less than the program evaluation which is Random Forest Classifier (7.89% inverted pair and 48% displacement) and Decision Tree Regressor (15.79% inverted pair and 44% displacement)

However, the analysis shows that the result from the program evaluation compared to the result from machine learning algorithms are not very different from and are not correlated with the scores from the traditional Thai dance teacher as it was expected.

V. Conclusion

In conclusion, this work reports the development and testing result of Thai traditional dance evaluation system for the Thai dance training tool project.

The evaluation method, at first, uses the formula to calculate the similarity percentage between user's movement and expert's movement. To test the performance, the scores from the evaluation method are collected and their rank is compared with the rank of scores given by the traditional Thai dance teacher from the College of Dramatic Arts by calculating the inverted pair and the displacement. This testing method gives 17.7% inverted pair and 53% displacement.

The results were not as good as expected, so the regression algorithms in machine learning were implemented to be used for evaluation instead of using the formula for calculation. After trying several regression algorithms, the results show that there are 2 algorithms that give better results than the formula calculated which are Random Forest Classifier that has 7.89% inverted pair and 48% displacement, and Decision Tree Regressor that has 15.79% inverted pair and 44% displacement.

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