Aesthetics of BharataNatyam Poses Evaluated Through Fractal Analysis

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Abstract Fractals are known for their aesthetic appeal. We have calculated the Fractal Dimension (FD) with the Box-Counting method for the *Adavus*, pure dance movements in BharataNatyam. These poses were found to be Fractal with the FD in the range of 1.3–1.5. This FD range has already been proved to be naturally aesthetically appealing to the human eye. Fractals have not been used so far for Indian Classical Dance (ICD) pose analysis. In this paper we have used FD for auto classification of system generated dance poses. This experimental study also reveals that the dance poses in the FD range of 1.5–1.6 are also found to be creative and appealing by the dance experts. Considering the classification ratings of system generated dance poses by an International dancer as Gold Standard data we have found that the Accuracy, Recall and F_Score to be 46 %, 52.63 % and 48.77 % respectively. The results are promising and encouraging for further research using FD with other parameters to measure the aesthetics of dance pose.

Keywords Fractal dimension · Box-counting method · Classification · Aesthetics

1 Introduction

Indian Classical Dance poses are very unique and sculpture like. BharataNatyam (BN) is one such major and well-known ICD that has been in existence for centuries and follows the ancient text of *NatyaShastra* (NS). This theory of ICD and Dramaturgy has not only laid down the rules for various choreographic practices but also allowed innovations in it. We have successfully experimented with Genetic Algorithms by modelling the human body [1] and were able to give various choreographic options [2, 3] for the pure dance movements of BN called as "*Nritta*". These

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dance poses were rated by experts from various dance schools and the average ratings were used as a training set for the untagged poses. We also used 2D Stick figures to display the modelled 30 attribute Dance Position (DP) vectors through [4] and used Rough Set Theory in [5] for reducing the dimensions of our 30 attribute DP vectors.

Our results of Single-beat [2] and Multi-beat Choreographic sequences [3] were heavily dependent on human experts for evaluation. We noticed that these dance experts could oversee sometimes the finer aspects of creativity such as novelty, complexity, unpredictability and surprise value due to mainly lack of time and interest. While analysing the averaged ratings data, we observed discrepancies in the ratings given by the dance experts. Although NS allows various innovations in the ICD, most of the choreographers and teachers always follow the same dance routine taught by their teachers. So while we experimented a system with several constraints to generate choreography, some of the experts were skeptical to follow and see a totally new dance sequence which they had not practiced or even heard of earlier.

Dance is learnt through rote system and there exists many choreographers who simply follow their teacher or *guru* without even thinking of the new possibilities. Thus, we noticed a clear bias mostly towards traditional choreography. In such a situation, where our system was generating novel moves that were unheard and unpracticed, it was very difficult to prove their expectation. Few teachers were extremely creative and accepted all the moves as the best ones while some of them rated only on their experience. Thus, we could not have a basic agreement and felt that these experts could oversee a potential good pose to a bad pose. The diverse ratings by them prompted us to use various measures for finding the aesthetic appeal of a pose. Fractal Dimension was one such measure which has helped us to determine the aesthetic quality of a dance pose.

Beauty lies in the eye of the beholder and hence most of the times we find it very difficult to quantify the measure of beauty. We introduced the same set of poses to different experts at different locations. Some found a pose to be lowest on the Likert scale ranging from 1 to 5 while others had innovative reasons to give a higher rating [6]. We could not come to a conclusion as to why certain poses were favourable than others, nor could the experts specify explicitly the parameters on which the ratings had been done. Due to such vast discrepancies we had to tag each picture as per the expert opinion and then finally an average rating was calculated for the same. Due to the law of averages, these ratings were giving a different interpretation to the same dance pose [6].

We had a total of 224 tagged instances out of which 130 were from the existing repertoire of BN called as *Adavus*.[1] We termed these *Adavu* as “Excellent” since they were taught by the teachers. The remaining of the dance poses were tagged by the experts as per their liking. Although we had expected them to rate our poses on a scale of 1–4 where 1 was “not acceptable” and 4 was “Good”, most of the experts

[1]Adavu(s): A basic step in BN, taught to a beginner and used for pure dance movement. They are aesthetically pleasing movements which can be used to convey no meaning in a dance sequence. They are rhythmic patterns helpful for building a beautiful sequence. They form the basic of learning dance just like alphabets are helpful in forming sentences.

were of the opinion that our poses were "Excellent" (5) and at par with innovative choreographic skills. Thus, they have rated few of the poses as 5 also. With the help of these trained data set (224 instances), we tagged unknown poses (277 instances). WEKA classified these unknown poses and gave us an accuracy of **87.42 %** for 501 instances. This proved to be better than the 66.9 % accuracy with the earlier 224 instances. To find out the genuineness of these ratings, we wanted to find a measure of beauty for a dance pose. These measures could help us in uniquely identifying the basis on which they were tagged. The art of BN choreography has a lot of aesthetic appeal and the reasons for choosing fractal geometry for verifying the same are explained in the following section in detail.

2 Related Work

Fractals for Aesthetics The numerical order in the apparent chaos of nature through self-similar repeating patterns at different scales has been found to be fractal in nature by the Polish-born mathematician Benoit Mandelbrot. He found various patterns in nature to be interesting and rated the roughness of natural objects such as the coastline of Britain, clouds, mountains, and trees, through its fractal shapes and the **Fractal Dimension (FD)** [7]. The human eye has been used to fractals everywhere around them says Richard Taylor and that is the reason why we find ourselves attracted to fractal patterns always unconsciously since we find it soothing. He also states that the eye is a natural fractal detector and has categorically proved in [8] how people have aesthetic preference for fractal images in the mid-range from **1.3 to 1.5** of its FD, irrespective of the method used to generate them by human with use of computer, maths or through nature.

Fractal Analysis Used in Dance FD through Box-Counting method was calculated through the several patterns generated on the floor by various Latin American Dances such as Salsa, Cha-cha, and Merengue by Tatlier et al. [9] and it showed that Rumba had the highest Fractal pattern with a FD of 1.36 while Merengue had the lowest FD score of 1.16. Our work presented here is completely different from the above. An inter-disciplinary work [10] involving mathematicians, scientists and dance artists used the Fibonacci Sequence and Golden Ratio along with digital images, movies and fractal-generating programs by a choreographer for a Dance show.

Some other measures of Image Aesthetics Visual Image Processing for aesthetic values have been explained through a formula by Machado et al. [11] in a different way. It states that higher the image complexity better is the aesthetics since processing complexity is also lesser. Additionally, he states that a tired state of mind chooses the images with lower processing complexity.

Dance Aesthetics The changing aesthetic preference of audience for classical Ballet was experimented with linear regression in [12]. Complex dance patterns are beautiful since they stimulate the brain says Hagendoorn [13].

3 Problem Statement

Aesthetics in the field of fine or performing arts is a very subjective decision. There are so many parameters which determine the choice of a particular piece of art that it becomes difficult to measure the importance of all these scales for a qualitative judgment. Some of the parameters could be the cognitive processing stages of the individual, emotional quotient, perceptual analysis, familiarity, personal taste (which can be a major variable), symmetry, order and so on. Thus, to automate this process we need to clearly define the aesthetic parameters for every individual. The Accuracy, Precision, Recall and F Score for the three experts are shown in Table 1.

Dance Choreography is a highly creative domain. Our ArtToSMart (System Modelled art) system generated novel choreographic suggestions for pure dance movements of BN [3]. The expert ratings of these BN poses and consequently for the multi-beat sequences [6] showed that every individual had a different taste. Thus, it was an up-hill task for us to generalize the situation. We tried to average their scores and classify them through Machine Learning techniques [5]. This resulted in a higher accuracy for the newly created instances. To verify the correctness of the classification, we had to ensure some additional measures for tagging the dance poses.

Fractal art has an aesthetic appeal of its own but for this paper our task is to find the fractal dimension for each expert and display those poses which are in their choice range. Spehar et al. [8] have already proved the universal aesthetic appeal of a fractal for the range of 1.3–1.5. Hence, we need to evaluate the FD of images to get an idea whether our poses are really having an aesthetic appeal and also to check whether they are fractal or not. So we used the Box-Counting measure for calculating the FD of the rated images.

4 Implementation Details

A study of various applications using fractals showed the methods available for the fractal analysis. Also this study revealed the use of a well-researched software like ImageJ [14] for fractal analysis. Its an open source, Java-based, public domain image processing software providing several plugins and macros for various different platforms.

Table 1 Precision, Recall, Accuracy, and F_Score for of "Good" DP images

Expert	Precision (%)	Recall (%)	Accuracy (%)	F-score (%)
1	45.45	52.63	46.0	48.77
2	33.0	45.45	37.28	38.23
3	42.00	50.00	43.63	45.65

4.1 Box Counting Method

We have used the Box Counting method for fractal analysis [15] which is widely used to determine the FD of an image. In this method, the image is covered with grids of various sizes and then the box covering the image is counted for several magnifications. This procedure is repeated for shrinking box sizes and the data are plotted on the X–Y plane. The value of Log(N) is plotted on the Y-axis while Log(r) is plotted on the X-axis. N represents the number of boxes that cover the pattern and r is the magnification scale. The FD is the slope of the line which is defined by the following equation $D = Log(N)/Log(r)$. Linear Regression is used to find the line of best fit for the data. The nature of the images can be conformed to be fractal if they are linear, i.e. the fractal patterns are data on a straight line. FD are one of the most important parts of fractal Geometry because it takes into account the changing nature of the pattern due to measuring with smaller magnification scales. Thus, with the increase in structural complexity the FD value shall also increase and higher FD could signify the image's higher artistic value. Thus, the degree of complexity can be measured by evaluating how fast the measurements change depending on the change of the magnification scale.

4.2 Fractal Analysis of "Adavus"

More than 50 pictures of *Adavus* were analysed and we have found that they were in the range of 1.3–1.5 ($\pm\delta = 0.03$ to 0.05). This already shows that they are aesthetically pleasing since they are in the range of fractals. This clearly proves that BN poses are also fractal in nature. These *Adavus* are geometrical in nature, i.e. according to the dance texts these poses form various angular movements of triangle, rectangle, square, circle, etc. [16, 17] and are always symmetrical in nature thus keeping the Euclidean Geometry [17] intact. We need to verify the FD of some new poses other than *Adavus*. These poses are deviating from Euclidean Geometry and hence will have higher FD. Our dance poses generated by the ArtToSMart software are not always self-similar unlike nature's fractals or even as seen in the *Adavu* patterns and hence Box-Counting method is the most appropriate to evaluate them. The *Adavu* patterns have lesser FD as compared to the generated images since they are symmetrical and geometric in nature.

4.3 Data Preparation for ImageJ Software

We have used the Box Counting method for fractal analysis. Two of the well-studied techniques of Box-Counting Method are for Binary and GrayScale images and hence we chose to use ImageJ for converting our coloured images to the binary mode.

4.4 Experimental Results

Aesthetic choices can be different due to variety of factors such as age, familiarity, creative skills, temperament and so on. Thus, it was not an easy task to find the exact fractal dimension which could cater to everyone's needs. This study also showed that although the preferred FD range is 1.3–1.5 for images (as seen in Sect. 2 earlier) [8], the expert liking is more in the range of 1.5–1.6 ($\pm\delta = 0.08$) for our system generated dance poses. Another important feature to be noted while calculating FD was that each image was dependent on the costume worn by the dancer. This was affecting the result of the FD. The finer gestures of BN, the leg positions and the costume problems were tackled to some extent with the help of finding the edges of the figure through the ImageJ software. While converting these images some of these information was lost to some extent. Since a novice in BN will find it difficult to understand the intricate hand and foot patterns, it has to be noted that this study can help experts or BN connoisseurs only. In addition to the factors mentioned above, we also notice that the human mind has a liking for certain objects depending on their temperament and various other factors like the time of the day, inclination towards new ideas and many more facets. This study helped us in generalizing aesthetic content in a certain way. Considering the consistency showed for majority of the images ranked by any individual, we can generalize the trend for their liking. It may not hold true for every single image but overall the results are promising.

4.5 Estimation of FD Range for BN Dance Classification

After calculating the FD range for *Adavus*, we analysed around 100 odd DP images generated by our system (the Genetic Algorithm driven ArtToSMart system can generate several DP vectors at every time and we had around 2000 such DP vectors in the database. We selected around 100 odd DP vectors and with the help of our dance expert modelled it into DP images). These were rated by 9 experts who performed at International, National and State levels on a scale of 1–5 where 1 (Not Acceptable) was the least and 5 (Excellent) was the highest. We noticed that 93 DP images had a higher rating from atleast one of the experts. Thus, we tabulated these pictures on the basis of being liked by more than 50 % of experts. This resulted in 32 such images which were either tagged as "Excellent" or "Good". Here, it was noticed that the highest FD was of 1.68 while lowest was 1.42.

With 98 % confidence level, we could prove that *Adavus* were in the pleasing range of 1.42–1.46 (Table 2) and so on for others with help of standard normal probability variable. The confidence intervals were calculated with Z statistic measures.

On the basis of this proved FD range as seen in Table 2 we created a confusion matrix for 3 experts of International, National and Local repute. Due to space constraint, we have displayed here Expert 1 and 3 only as seen in Tables 3 and 4, respectively. Due to the new statistically estimated FD, we found many instances that were

Table 2 Statistically estimated FD for the BN poses

Tag	Fractal dimension
Excellent (Adavu)	1.42–1.46
Good	1.54–1.58
OK	1.57–1.61

Table 3 Confusion matrix for Expert 1

Statistically predicted				
Expert	Excellent	Good	OK	Total
Excellent	0	3	6	9
Good	0	**10**	9	19
OK	0	9	13	22
Total	0	22	28	50

Table 4 Confusion matrix for Expert 3

Statistically predicted				
Expert	Excellent	Good	OK	Total
Excellent	2	3	4	9
Good	0	**11**	11	22
OK	1	12	11	24
Total	3	26	26	55

beyond the bound. We have not considered these data while calculating these scores. For, e.g. anything below 1.42 or above 1.61 was categorized as others in the confusion matrix. This resulted in 16, 23 and 24 instances not being in the confusion matrix for the three experts, respectively. Although the accuracy is not very high but we can still say that images in the statistically proved fractal range are aesthetically pleasing because they are complying with the fractal standards.

5 Conclusions

Domain experts are unable to articulately point out the measures which define the beauty of a dance pose. There were several factors mentioned such as familiarity, symmetry, creativity and so on, but we could not summarize all of them to give a common aesthetic appeal to every picture. Thus, we chose a unique methodology to identify the aesthetic appeal of a dance pose which shall also help us in the classification process. FD gave us an idea of the liking and disliking for every individual. Such findings on a bigger tagged data set can help us to refine the classification process of all unknown poses. The more the complexity of the pose, more is the FD and our experiments have revealed the same. Some experts may find these images to be highly creative while others may not like the same. Our findings show that the highest ratings by them are for the FD from 1.5 to 1.6.

The FD may differ due to the following reasons: costumes worn by the dancer, angle of photography, background, imperfection in the dancer posing in front of the camera and so on but given similar environment of the above parameters, the results shall remain consistent. Thus, we can successfully conclude that any dance pose that is fractal is pleasing to the eye (1.3–1.5) and creative if within the permissible range of 1.5–1.6. If we use additional measures along with FD for aesthetic preference of a dance pose, we can definitely come up with a full proof formula for automated classification of BN dance poses.

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