Computer algorithm classified artwork for generative design

Ahlam Bavi
Iran, University of Tehran, College of Fine Arts
http://wtiau.ac.ir/en
Lior Shamir
United States, Lawrence Technological University, College of Engineering
https://www.ltu.edu/
Tang Ming Xi
Hong Kong, the Hong Kong Polytechnic University, School of Design
http://www.sd.polyu.edu.hk/en
Yagub Ajand
Iran, University of Tehran, College of Fine Arts
http://ut.ac.ir/en

Abstract:

The work of detecting artwork by art scholars is a very complicated task. It gets much more complicated when it is done by computer algorithms. In the past studies, researchers have tried to do the manner of detecting forms analysis based on such software such as the WND-CHARM without man's intervention. This software was initially used for molecular biological analyses applied based on comprehensive set of numerical descriptors. Numerical descriptors are formed for image contents features that reflect many aspects of visual contents such as shape, edge, statistical distribution of pixel intensity, fractal feature, and polynomial descriptors are decomposition of the image.
By converting quality to quantity by the software, qualitative artwork can be divided into a range of numbers with basic meanings and, ultimately, numbers will compare in quantitative systems the qualitative cases. Numerical values derived from artwork can be considered as biological genes, which, according to the principles of genetic science, result in human distinctions. These genes contain qualitative information that is visualized by the creation of artwork. In the present research, the art of NegarGari as one of the most important forms of painting in Iran will be analyzed.
In the present study, a dataset of 660 NegarGari are chosen for analysis by WND-CHARM in respect to their visual contents. Datasets belong to different periods of the

Persian Islamic dynasties. Three experiments were designed for this study to automatically determine similarities in images. Thereafter, data were converted to codes to be comparable with each other by computer. Finally, the classification of artworks was done by computer based on the resultant similarities. Moreover, the similarity exploration was done in respect to different art schools, genre of painting, and painters. Experimental results showed that automatic computer analysis can group painters by their artistic movements, and provide a map of similarities and influential links that is largely in agreement with the analysis of art historians. These results demonstrated that machine vision and algorithms are able to mimic complex cognitive tasks of the human perception of visual art, and can be used to measure and quantify visual similarities between paintings, painters, and schools of art.

The research has shown that the algorithm analysis is able to translate the qualitative artworks to quantitative ones. The Generative art is based on algorithmic principles so in the future of this kind of research, we can achieve of a new kind of generative art derived from artwork. So that by these numerical values we can find the artworks belonging to a same family but distinguished from the previous works of art.

The effort made in this study does not mean that human intervention is completely eliminated but in the first stage, i.e. the selection of works of art, this intervention prevails. The purpose of this research is to examine the computer's ability to recognize artwork and finding out how algorithms automatically determine paintings similarities and classified them based on their similarity that is broadly in agreement of art historians.

The 3 experiments were designed for this study to find the similarities between paintings of different Persian Islamic dynasties and determine similarity of their artistic style; also computer will find the similarities between the different art schools, genres of painting and painters. In the following section, we will describe the dataset, the method of images analysis and at the end; the graphs will demonstrate the results of experiments.

Image dataset

The Muslim conquest of Persia, also known as the Arab conquest of Iran, led to the end of the Sasanian Empire. The Muslims took over the provinces of Persia one by one and eventually conquered the whole Empire.[1]

One of the visual cultural heritages is painting[i] that changed through the ages. The religious view of Muslim has had a strong impact on Persian painting that called NegarGari[ii], it is extremely difficult to study the early Islamic NegarGari in Iran, and the main two problems are: [13]

1. the figurative painting was forbidden in Islamic manner therefor NegarGari was not popular in society and was merely used for designed books in small size[iii]
2. the other one is not accessible images for early period because most of them are damaged

Meanwhile, for this study only a few Persian Islamic dynasties were chosen because of the most existence images such as Umayyad Dynasty, Abbasid Dynasty, Seljuq Dynasty, Mongol Dynasty, Timurid Dynasty, Safavid Dynasty, Afsharid-Zand dynasty, Qajar Dynasty and Pahlavi Dynasty. [1]

In previous study[iv] the source of the images were from various on-line sources using basic internet queries, to ensure that the computer analysis will be based on the visual content, if the sources been the same, some artifact and source-specific features might be effected the computer analysis.
The online source of NegarGari are little and the most of them are valuable non accessible antique artwork and have been kept in personal collection or galleries, for this reason we tried to use other sources like photography images and scanned files.
We tried not to use all the images for one collection from one sources, because if all collection of one Dynasty were from online web site and the collection of other Dynasty was from the scanned file, the similarities of the source can lead to severely biased results we tried to all the images being in their original condition preserving the original aspect ratio.[v]

For computer analysis, all the images must be in normalized size, for analyzing the western European paintings all dataset was normalized to 640,000 pixels,[vi]As previously mentioned, Persian's NegarGari are smaller than western European paintings therefor all dataset normalized to 1024*876 almost about 800.000 pixels.[5]

It was expected that uses the sampling method to make the analysis more meaningful for comparing similarities[vii] and for each experiment the specific number of images used but about the less number of Persian's NegarGari and the unknown ones in this paper we use censes instead of sampling method, at least the dataset includes 660 NegarGari representing 61 known painters chosen. By senses in each run the number of images that randomly selected to determine the Fisher discriminant scores of the features was different, and the number of repeated experiment was different too.

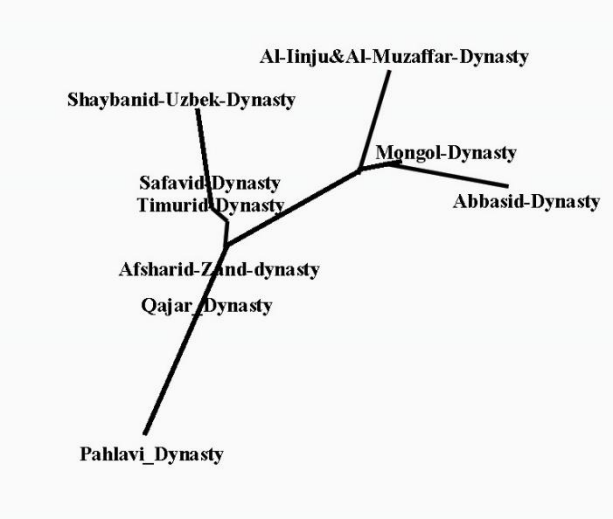
Image analysis method

The image analysis method is based on the WND-CHARM scheme [7], which was originally developed for biomedical image analysis [3]. The CHARM [8-9] set of numerical image content descriptors is a comprehensive set of 4027 features that reflect very many aspects of the visual content such as shapes (Euler number, Otsu binary object statistics), textures (Haralick, Tamura), edges (Prewitt gradient statistics), colours [6], statistical distribution of the pixel intensities (Multiscale histograms, first four moments), fractal features [13], and polynomial decomposition of the image (Chebyshev statistics). These content descriptors are described more thoroughly in [7-8-9-10]. This scheme of numerical image content descriptors was originally developed of complex morphological analysis of biomedical imaging, but was also found useful for the analysis of visual art [10-13].
An important feature of the set of numerical image content descriptors is that the colour descriptors are based on a first step of classifying each pixel into one of 10 colour classes based on a fuzzy logic model that mimics the human intuition of colours [6]. This transformation to basic colour classes ensures that further analysis of the colour information is not sensitive to specific pigments that were not available to some of the classical painters in the dataset, or to the condition and restoration of some of the older paintings used in this study.
Once numerical image content descriptors are computed, each feature is assigned

with a Fisher discriminant score, as defined by Equation 1 where Wf is the weight assigned to the feature f, Tf is the mean of the values of feature f in the entire dataset, Tf,c is the mean of the values of feature f in the class c, and f,c is the variance of feature f in the images of class c. Fisher discriminant scores can be conceptualized by the variance of the values of a certain feature across the image dataset, divided by the mean of the variances of that feature within the classes.
Then, the image features are ranked by their Fisher discriminant scores, and the 50% of the image features with the lower Fisher scores are rejected. The distance dI,P between each image I to each painter P is then measured by using Weighted Nearest Distance method, with the Fisher scores used as weights [8] as defined by Equation.[2]

Experiments results

WND-CHARM method was used for computer analysis of the Persian NegarGari. 5 experiments were designed to find the similarities of Muslim Iranian dynasties, art schools, painters and the similarities of painters by Portrait genre and the phylogenies generated for Muslim Iranian dynasties and the art schools are shown in Figures 1 to 5, respectively Portrait genre and the number of human figures in Figure 6 to 10.
Experiment 1 was designed to find the similarity of Muslim Iranian dynasties, the dataset of 651 images was participate in experiment and the figure 1 shows, the phylogeny reflecting the result. This experiment was done once and the number of training images was 25 for each dynasty. In this experiment, only the certain numbers of dynasties that have at least 25 paintings participate in experiment and the other dynasties did not shown in phylogeny because of the less number of their painting like Umayyad- Dynasty and Seljuq-Dynasty. As the figure shows, dynasties from early time are placed in the upper part of the phylogeny, while dynasties from late time are clustered in the lower part. It is noticeable that the computer was able to correctly cluster dynasties that belong in the same century, and placed these clusters on the graph in a fashion that is largely in agreement with the analysis of historians.



The figure1: reflecting the similarities between Muslim Iranian dynasties

In experiment 2 the metadata is art school and the dataset of 660 images from 18 art

schools was participate in experiment, this experiment repeated 4 times with different training images and featured used. First of all 22 images was used for training and the% of feature was 0, in second experiment number of training image was the same but the 15% of feature was used, in the third one number of feature was the same but 35 images was used for training and in the last experiment, number of training image was the same but the 30% of feature was used. Figure 2 to 6 shows, the phylogeny that reflecting similarity of art schools.

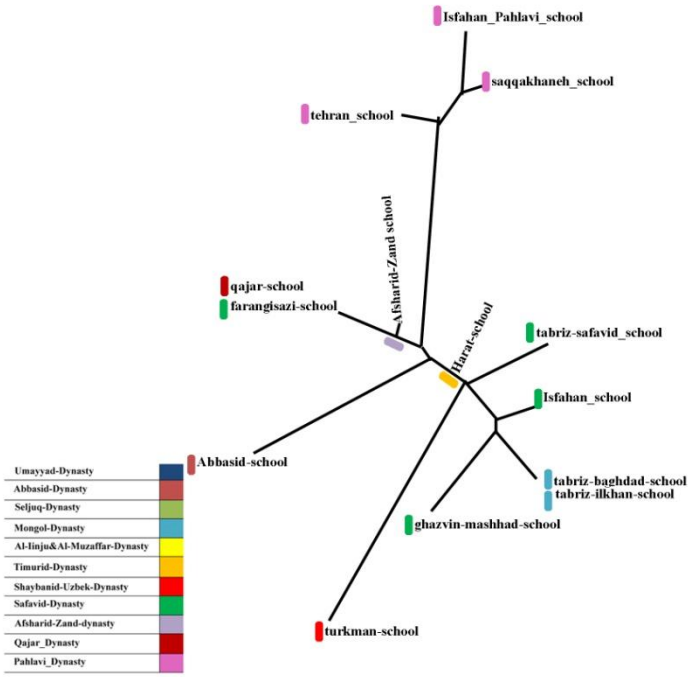


Fig 2. Reflecting theexp4_i22_j2

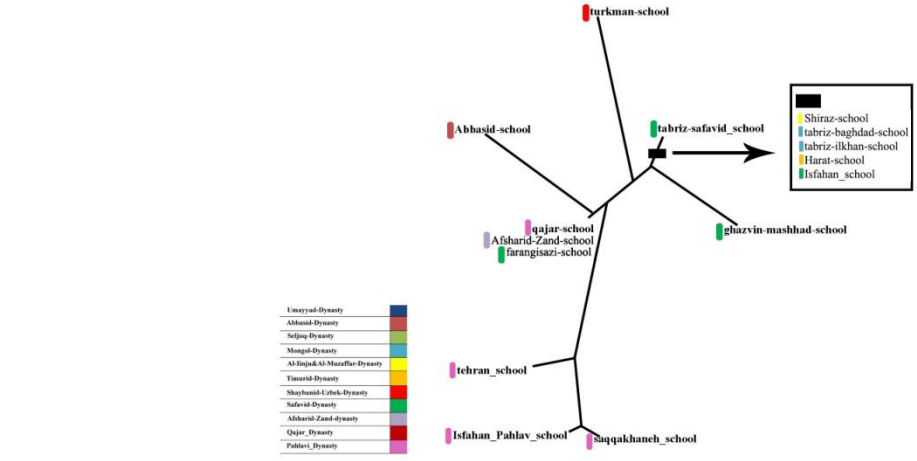


Fig 3. Reflecting the similarities between art schools exp4_i22_j2_f15

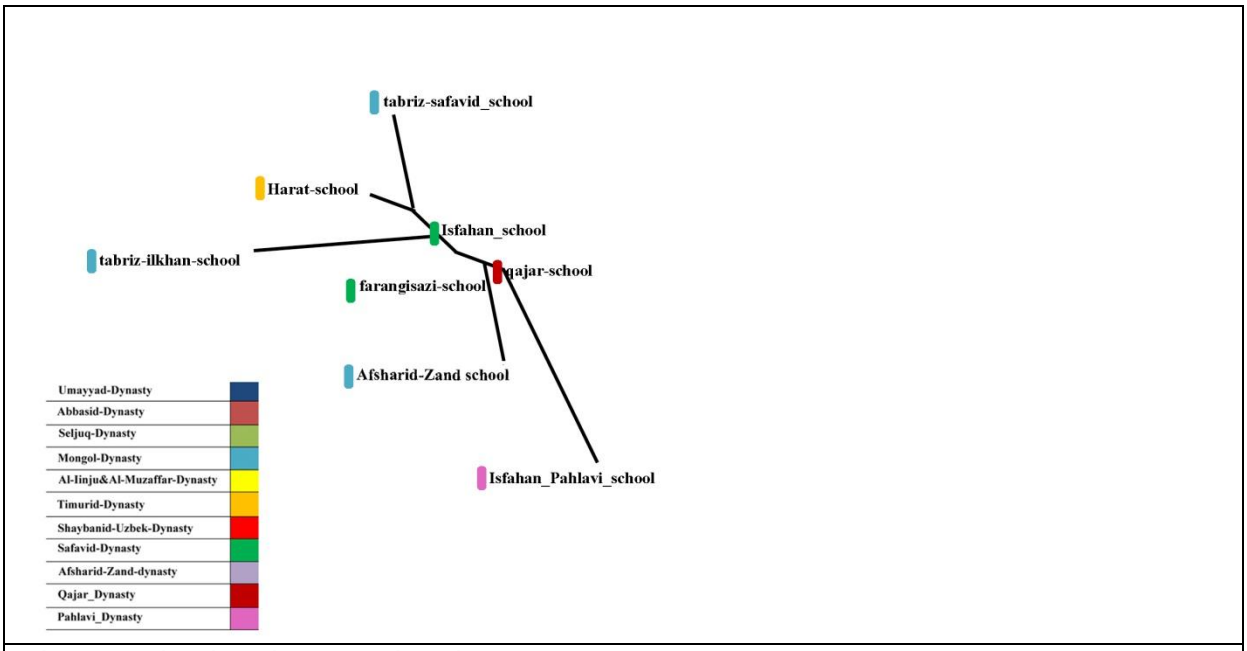


Fig 4. Reflecting theexp4_i35_j2_f15

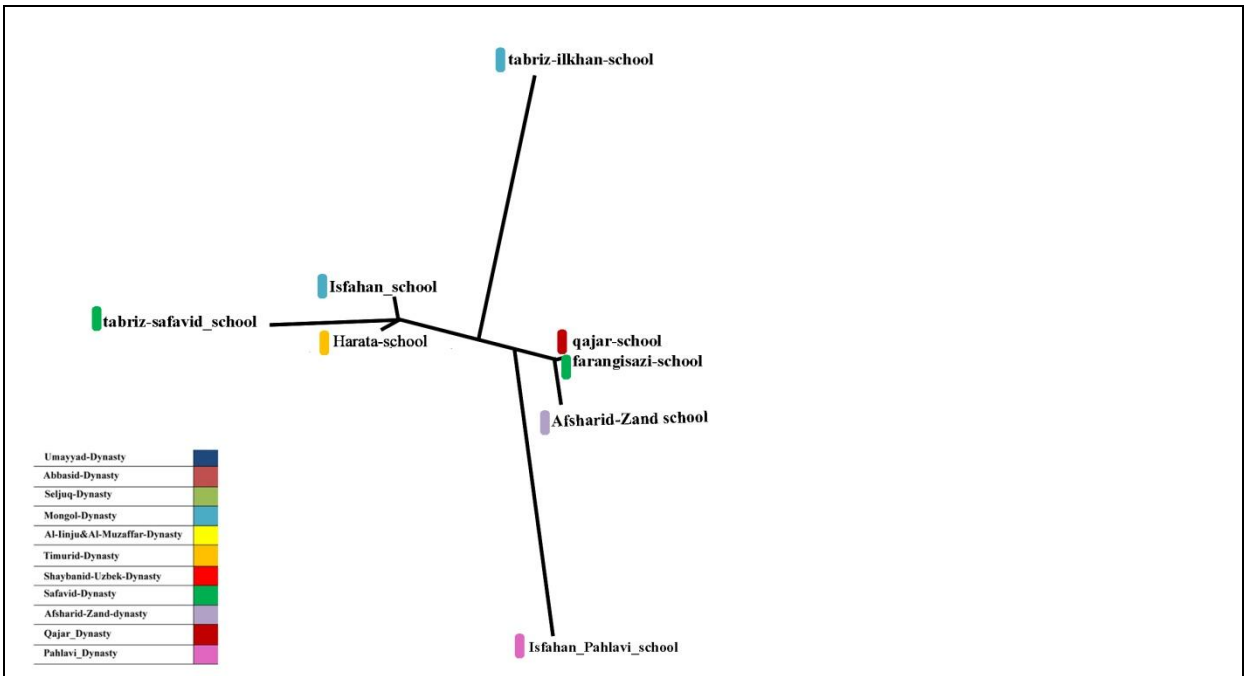


Fig 5. Reflecting theexp4_i35_j2_f30

Experiment 3 was designed to find the similarity of the 61 known painters, for this reason, 25% of the numerical content descriptors used and the experiment was repeated 99 times such that in each run different images were randomly allocated to training and test sets, the experiment was done two times, first of all the number of training images was 12 for each painter, therefor only 8 painters that have at least 12 painting are shown in figure 6. The lower part of the phylogeny features painters from Pahlavi dynasties, while the upper part includes Behzad and Siyah_ghalam from

Timurid dynasty. Muhammad_ghafari_kamalolmolk and Gholer_aghasi are painters belong to Qajar and Pahlavi dynasty, but they are placed next to painters from Timurid dynasty and Abolhasan_ghafari_sanieolmolk is a painter belongs to Qajar dynasty but he is placed next to painters from Pahlavi dynasties.

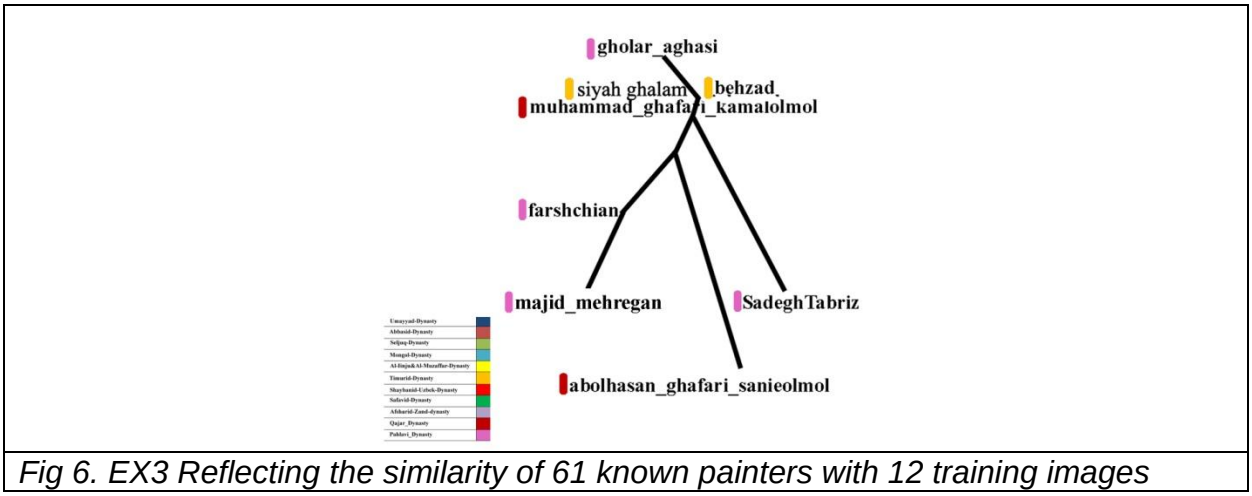


Fig 6. EX3 Reflecting the similarity of 61 known painters with 12 training images

Second of all the number of training images was 15 therefor only 7 painters that have at least 15 painting are shown in figure 7, the lower part of the phylogeny features painters from Pahlavi dynasties, while the upper part includes Timurid painter, Behzad and Siyah_ghalam. Muhammad_ghafari_kamalolmolk is a painter belongs to Qajar dynasty, but he is placed next to the painters from Pahlavi dynasty and Abolhasan_ghafari_sanieolmolk is placed in the farthest way from Muhammad_ghafari_kamalolmolk. The result shows that when the numbers of training images raise, the accuracy of the result are more in agreement with art historian.

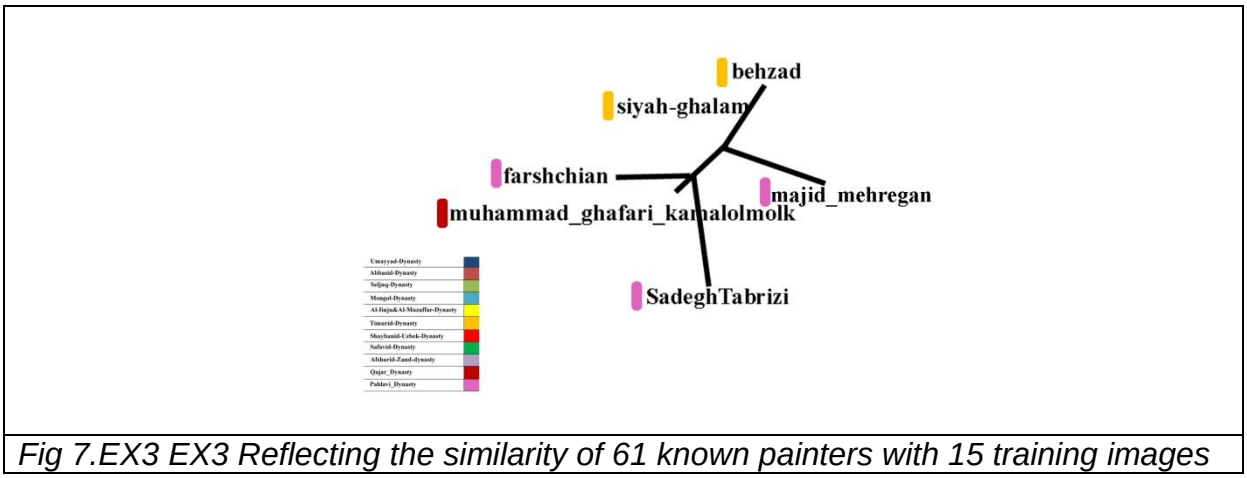


Fig 7.EX3 EX3 Reflecting the similarity of 61 known painters with 15 training images

Experiment 4 was designed to find the similarity of the 31 known painters that have works of portrait genre. The experiment was done three times, in each run, the experiment was repeated 20 times. First 15% of the numerical content descriptors were used and the training images were 7 for each painter therefor only 12 painters that have at least 7 paintings are shown in figure 8, at the left side of the painter from Pahlavi dynasty are places together and Muhammad_ghafari_kamalolmolk the painter of Qajar dynasty is again placed next to the painters from Pahlavi dynasty and Abolhasan_ghafari_sanieolmolk is placed in the farthest away from him, other

painter are not satisfactory placed.

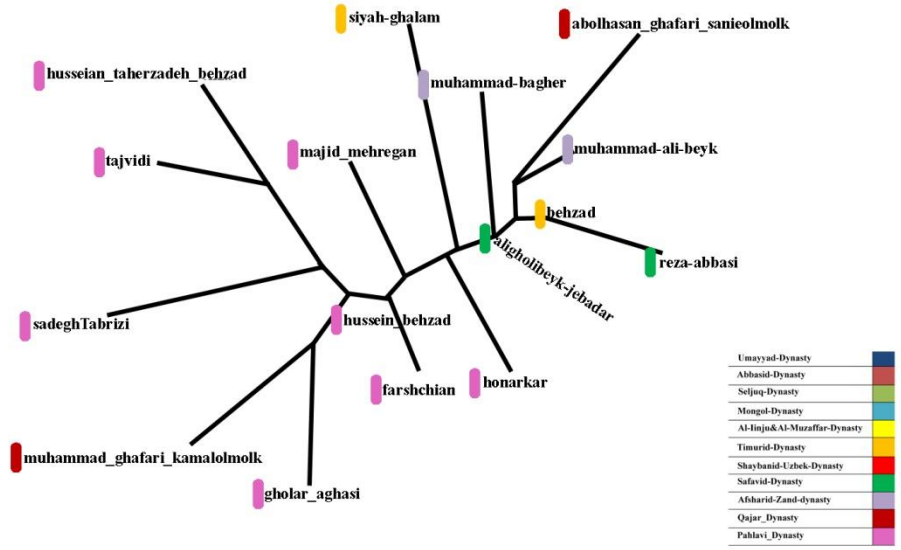


figure 8: number of training images was 7 and 15% of features used was

Secondly, the number of training images was raised to 9 and the results were mostly the same as the previous analyse.

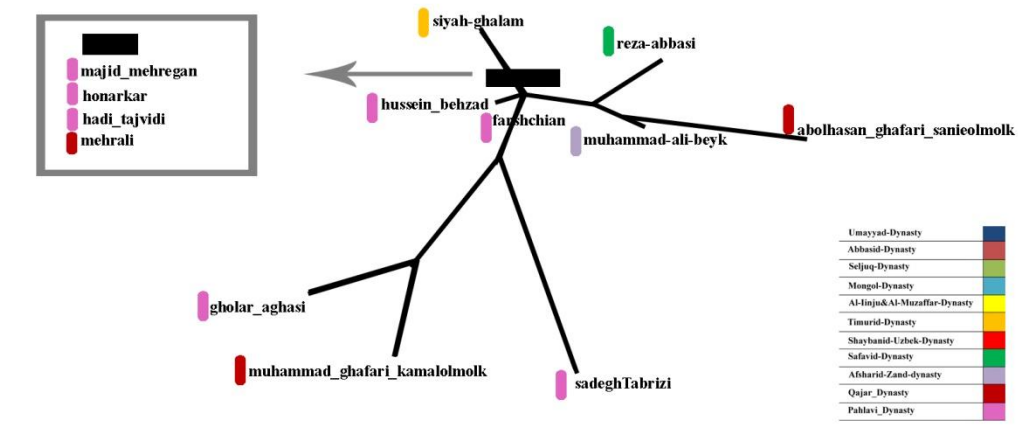


Fig 9. number of training images was 9 training images and 15% of features used

At last, when the numerical content descriptors was raised the results were satisfactory, upper part of the graph includes Pahlavi painter Muhammad_ghafari_kamalolmolk the painter of Qajar dynasty is again placed next to the painters from Pahlavi. In the middle part of the phylogeny, the pair of Timurid painter was show together; Behzad and Siyah_ghalam. Reza Abbasi and aligholibeyk-jebadar painters from Safavid dynasty are close to Timurid painters in agreement of art historian and

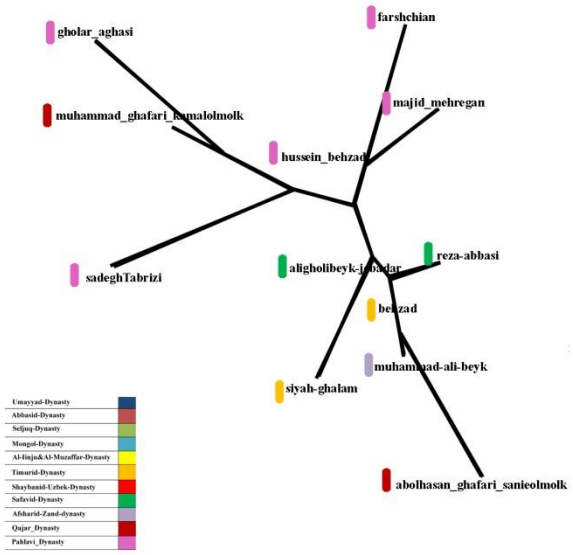


Fig 10. EX4Reflecting the similarity of the 31 known painters that have portrait genre with 9 training images and 30% of features used

It is noticeable that in all graphs from experiment 4, the computer was able to correctly cluster most of the painter from same dynasty, for example: all painters from Pahlavi dynasty are placed in fashion that is largely in agreement with art history, and the pair of Timurid painter was show together; Behzad and Siyah_ghalam But there is some exception like Muhammad_ghafari_kamalolmolk that is not belong in Pahlavi dynasty but is placed in the farthest away from Abolhasan_ghafari_sanieolmolk, this result show that Pahlavi painters are inspired by Kamolmolk and the Saniolmolk was far away the modern era.

Conclusion

By converting quality to quantity by the software, qualitative artwork can be divided into a range of numbers with basic meanings and, ultimately, numbers will compare in quantitative systems the qualitative cases. Numerical values derived from artwork can be considered as biological genes, which, according to the principles of genetic science, result in human distinctions. These genes contain qualitative information that is visualized by the creation of artwork. In the present research, the art of NegarGari as one of the most important forms of painting in Iran will be analyzed.

The Iranian NegarGari with its long history has always been considered an empty art free of fundamental changes during different periods. Therefore, with the research done, it is understood that not only this art is not based on the same traditions, but also has many changes in its own nature.

The research has shown that the algorithm analysis is capable of translating qualitative artworks to quantitative ones. By comparing the quantitative comparison of the qualitative works, it is possible to open the way for the recognition of artwork with higher precision and refrain from individual decisions and human interventions. This research is just the beginning of the acquisition of generative artworks based on algorithmic principles. So that by these numerical values we can find the artworks belonging to a same family but distinguished from the previous works of art.

The process followed in the present research is based on biological analysis software that has been used for many years to understand biological distinctions. But this can be reflected in the philosophical debates, and indeed it is the biological and phenomenological analysis of generative and non-generative artworks. The view of Gilles Deleuze as one of the new philosophers who founded the foundations of his philosophy on scientific principles. Biology as a science that first approaches the problem of life as a systematic and cognitive approach is Deleuze's defining tool. He defines the potential teachings that have the same pre-existing qualities and practical implications in the organism of the universe by genetic science and as a form of difference. Deleuze can be considered as the master-mind of the phenomenological studies in the future of this research.

[i] toward an aesthetic of Persian painting
[ii] NegarGari is verb and Negareh is noun
[iii] the study of painting and the art of the book
[iv] Computer analysis
[v] Computer analysis
[vi] Computer analysis
[vii] [Shamir, 2008; Shamir et al. 2008; Shamir et al. 2009; Shamir et al. 2010]

References

[1] Binyon, L. et al. 1935. Persian Miniature painting.

[2] Levy, E. 3013. Painter classification genetic algoritm.

[3] Mirrazavi, F. 2009. Persian Miniature. Iranreview.

[4] Landa, M. 2001, Deleuze and the Use of the Genetic Algorithm in Architecture.

[5] SHAMIR, L. et al. 2012.Computer analysis of art.

[7] SHAMIR, L. 2006. Human perception-based color segmentation using Fuzzy Logic.

[8]SHAMIR, L. 2008. Evaluation of face datasets as tools for assessing the performance of face recognition methods.

[9] SHAMIR, L. et al. 2008. Wndchrm - an open source utility for biological image analysis.

[10] SHAMIR, L. et al. 2009. Knee X-ray image analysis method for automated detection of Osteoarthritis.

[11] SHAMIR, L. et al. 2010. Impressionism, expressionism, surrealism: Automated recognition of painters and schools of art.

[12] SHAMIR, L. 2011. Assessing the efficacy of low-level image content descriptors for computer-based fluorescence microscopy image analysis.

[13] SHAMIR, L. 2012. Computer analysis reveals similarities between the artistic styles of Van Gogh and Pollock. Leonardo.

[14] Tabarestani, S. et al. 2015. Painting style classification in Persian Miniatures.