Mathematical Sciences and Informatics Journal
Vol. 3, No. 1, May 2022, pp. 100-110
http://www.mijuitmjournal.com DOI : 10.24191/mij.v3i1.18303

Redesign Arabic Calligraphy Outline by using Bezier, Wang-Ball and Said-Ball Curves

Noorehan Awang
Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Negeri Sembilan Branch
Seremban Campus, Negeri Sembilan, Malaysia
noorehan@uitm.edu.my

Fatin Najihah Ghazali
Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Negeri Sembilan Branch
Seremban Campus, Negeri Sembilan, Malaysia
2017412448@uitm.edu.my

Siti Sarah Zainuddin
Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Negeri Sembilan Branch
Seremban Campus, Negeri Sembilan, Malaysia
2017128521@uitm.edu.my

Article Info

Article history:

Received Feb 05, 2022
Revised Apr 15, 2022
Accepted Apr 28, 2022

Keywords:

Bezier curve
Wang-Ball curve
Said-Ball curve
Arabic Calligraphy
Degree elevation

ABSTRACT

In the history of the revitalization of traditional art in the modern world, Arabic calligraphy was one of the art phenomena. This research suggests using Bezier curves, Wang Ball curves, and Said-Ball curves to improve Arabic calligraphy. Our goal in calligraphy is to achieve a smooth beautifying contour of a character. The calligraphy outline, which was largely Arabic, was frequently applied in Bezier curve degrees two and three. As a result, the degree elevation for each curve was increased until it reached degree four, allowing for greater Bezier curve study. This paper presents the comparisons between those three curves by using the Arabic calligraphy "Aamin" as the subject. Curve fitting, curve manipulation, mixing, and merging of curves were all examples of how Bezier curves were employed in Computer Aided Design. Ball curves, also known as a generalized ball basis, are a type of curve that has arbitrary even and odd degrees. There were two types of generalized ball curves: Wang-ball curves and Said-ball curves, each with their own special position parameter. The best curves of the Bezier, Wang-Ball, and Said-Ball curves were combined to create "Aamin" calligraphy. All of the results were programmed into the MATLAB software and graphed. For the redesign “Aamin” calligraphy Bezier curve computes the best time compared to Wang-Ball and Said-Ball curve. The computation time in MATLAB software for the degree 2, degree 3 and degree 4 are 1.48 seconds, 1.52 seconds and 2.50 seconds respectively. The higher the degree elevation, the longer the computation time to generate "Aamin" calligraphy, according to these findings. This research provides the fundamental design and empirical findings in the process of improving the production of computerized Arabic calligraphy.

Corresponding Author:
Noorehan Awang
Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Negeri Sembilan Branch
Seremban Campus, Negeri Sembilan, Malaysia
email: noorehan@uitm.edu.my

1. Introduction

The mathematical description of employing shape for use in computer graphics, production, and analysis is known as Computer Aided Geometric Design (CAGD). Curves and surfaces were employed in a number of ways in computer graphics. To name a few, Curves include Bezier, Wang-ball, Said-ball, and NB1 curves. Bezier curves can be described by any degree n. The curve is

PENERBIT PRESS
UNIVERSITI TEKNOLOGI MARA

contained in the convex hull of the defining control points; the curve always passes through the first and last control points; and the degree of the polynomial defining the curve segment is one less than the number of defining polygon points. Bezier curves have seen recent advancements in robotics, particularly in the area of path planning and generating [1]. The parametric curves are used in engineering studies in the domain of multi-material flow [2].

The Bezier parametric curves are also used in ocean research to evaluate reflected photos and to create appealing automotive surfaces [3]. Some of the most common applications are in Computer Graphics, Animation [4], and Virtual Reality [5], among others. These and many other real-world Bezier curve applications make good use of the fundamental notions. As a result, this work demystifies evolutionary notions in parametric Bezier curves that are relevant to computer graphics, including as theorems, proofs, algorithms, and computations.

Two forms of novel generalized ball curves were the Wang-Said generalized ball curve and the Said-Bezier curve with their respective position parameter. It could be made simpler by using a generalized curve that contains both a Bezier and a Said-Ball curve, or by switching between Said-Ball and Wang-Ball curves. It has two advantages: the recursive Said-Ball curve algorithm is twice as fast as the de Casteljau Bezier curve algorithm for calculating polynomial curves. Another advantage of Said-Ball is that degree elevation and reduction for a polynomial curve is considerably easier and faster in Said-Ball form. Using this new model, the problem of lack of strength in all state-of-the-art Computer Aided Design (CAD) systems can be considerably addressed [6-8].

From an etymological standpoint, calligraphy implies "beautiful lines or writing" in Arabic (tahsin al-khutut). Arabic calligraphy is one of the most well-known artworks, with a long history dating back to the Quran's revolution [9]. The origin ideas of Islamic calligraphy can be seen from two perspectives: religious and historical [10-12].However, according to this study, Bezier curves, Wang Ball curves, and Said-Ball curves can all be used to improve Arabic calligraphy. Our goal is to achieve a character's smooth beautifying contour while also allowing for the filling of the inner area.

2. Literature Review

The notion of Bezier Curves was developed by Pirerre Biezier [13], who is credited with using it in the design of automotive chassis. A smooth parametric curve controlled by the geometry of a defining polygon is known as a Bezier curve. The defining polygon is made up of a convex hull [14], which is made up of a number of points known as control points [15]. The number of control points equals the order of a Bezier curve. According to a recent study, bezier curves have also been used for fingerprint extraction, which uses the cubic Bezier curve technique, which is one of the best ways to represent fingerprints. The straight-line angle created between each sequencing control point will determine "for each portion" whether a new Bezier curve is required or whether this part can be merged with the preceding and represented as a single Bezier curve. The acquired results suggest that the intended method can reduce the number of Bezier curves, but the number of Bezier curves and the quality of the resulting image are both dependent on the number of segments[16].

The generalized blended trigonometric Bernstein (or GBT-Bernstein, for short) polynomial functions of degree m are produced in this study [17] using a novel recursive formula in explicit formulation. Generalized blended trigonometric Bézier (or GBT-Bézier) curves with two form parameters are also created using these basis functions, and their geometric properties and applications to curve modelling are examined. A new technique for determining the control points of a Bezier curve was proposed in the other paper [18]. The algorithm then solves the mathematical problem by expanding the generalized Bezier curve equations, eventually forming the simultaneous equation for control point creation. The produced control points will be able to produce a correct Bezier curve that passes through all of the path's selected points.

Wang-Ball used the two surfaces to develop new calculations for evaluating parametric surfaces, and the results suggest that these calculations are more powerful than de Casteljau's. The state of cubic Wang-Ball capacities in terms of the number of focuses required, equivalent to cubic Bezier capacities. It is possible to create a time-efficient algorithm for evaluating a rational Wang-ball curve [19]. The state of cubic Wang-Ball capacities in terms of the number of focuses required, equivalent to cubic Bezier capacities. Overall, this capability has a lot of potential, especially since a couple of studies have lately proven its advantages. Masters usually communicate their skill to build curves in less time. The property of end point commitment, on the other hand, makes this the greatest option for installing and finishing point by point. This method necessitates the use of a furthest point capable of implanting each curve changing point. As a result, an acceptable interplant can be produced [20] using the cubic Wang-Ball assumption.

Different kinds of structured matrices that measured to be a positive number of matrices were measured in Said-Ball numerical computing with a positive matrix in numerical linear. A Said-Ball is a generalized ball basis with arbitrary even and odd degrees. In a recent work, biharmonic cubic Said-Ball surfaces were used in the image enlargement area for a scaling factor of two. Using well-known gray-scale test images, the proposed method is based on the peak signal to noise ratio (PSNR) indicator. When compared to the well-known current bicubic convolution approach [21], the proposed methods for resizing sample grayscale photographs with a scaling factor of two produce equivalent accuracy in terms of image quality.

Said-Ball curve approach to find solutions to some natural Partial Differential Equations (PDEs) that can only be measured at border control locations and neighboring places. In the study, they use a lower-dimensional biharmonic Said-Ball surface with 16 control points, 12 of which are boundary control points, with a degree of 3 by 3. By using the biharmonic PDE, they can deduce a relationship between provided boundary control points and inner control points. Image extraction, profile approximation, fairing, smoothing, and modelization may all be done with ease using the Bezier and Wang-Ball curves [22].

Calligraphy is a graphical craft related with writing, according to [23]. Arabic calligraphy started out as a tool for correspondence, but it evolved into engineering, embellishment, and other forms of architecture over time. It is one of the most well-known art phenomena in the modern world's history of traditional art resurgence. Calligraphy can be found in a variety of styles and areas, including Chinese calligraphy, Japanese characters, and Arabic calligraphy. Chinese calligraphy is one of the best and most important kinds of art in China, as well as an inseparable part of its history. The Kai calligraphy style has crisp strokes and a well-designed framework, and it is also widely utilized, making it an excellent choice for beginners [24].

The process of encapsulating outlines, according to [25], comprises mostly of four parts. To begin, collect the blueprint (shape focuses) and then divide the diagram into curve sections and distinct corner focuses. Then, using cubic Bezier curves, calculate out the curve guess for each curve area. Finally, subdividing the curve part at appropriate points keeps the estimation blunder contained within the provided base cutoff points. Alternatively, by slightly adjusting the discrete data points, a new foundation to the same technique was tried, however as noticed during curve modelization, it does not automatically provide the given findings at the same time and may be repetitive and deficient. He proposed a curve fitting method based on form characterization, assuming a flat surface of Bezier curves with uniform and monotonous curvature variance and fixing degrees in the range of 3 to 5. The geometric conditions with a constant angle to each vertex and a constant ratio between the lengths of each adjacent edge were applied to the Bezier polygon to characterize the shape.

3. Methodology

3.1 Image of “Aamin”

The subject in this research was “Aamin” calligraphy, as seen in Figure 1. The plotting stage was then completed by using graph paper to locate a suitable point for use in the MATLAB software. The degree of curve for Bezier, Wang-Ball, and Said-Ball curves must be determined using the three approaches' core formulas.

Figure 1. “Aamin” calligraphy

3.2 Collect the information of Bezier, Wang-Ball and Said-Ball curves.

Bezier, Wang-Ball, and Said-Ball curves are three different methods used in this study to quantify performance. The following provides more explanation on these methods.

- **Bezier Curve**

The curve follows the shape of the control polygon, which is made up of segments connecting the control points; the curve is contained in the convex hull of their defining control points; the curve always passes through the first and last control points; and the degree of the polynomial defining the curve segment is one less than the number of defining polygon points. Equations (1) and (2) can be used to compute it.

$$B(t)=\sum_{i=1}^{n}V_iB_i^n(t) \tag{1}$$

where V_i is the set of point and $B_i^n(t)$ is the Bernstein polynomials which are given by equation (2).

$$B_i^n(t)=\binom{n}{i}t^i(1-t)^{n-i} \tag{2}$$

where n is the polynomial degree, i is the index such as $i=1,2,3,...n$ and t are the variable. A curve with a degree of two, for example, will be made up of three points.The calculation for the degree was shown in Table 1 by employing fundamental functions in equations (1) and (2).

Table 1. Calculation Bezier formula for degree 2 until degree 4

Bezier degree	**Degree 2**	**Degree 3**	**Degree 4**
Calculation for degree	$B_0^2(t)=(1-t)^2$ $B_1^2(t)=2t(1-t)$ $B_1^2(t)=t^2$	$B_0^3(t)=(1-t)^3$ $B_1^3(t)=3t(1-t)^2$ $B_2^3(t)=3t^2(1-t)$ $B_3^3(t)=t^3$	$B_0^4(t)=(1-t)^4$ $B_1^4(t)=4t(1-t)^3$ $B_2^4(t)=4t^2(1-t)^2$ $B_3^4(t)=4t^3(1-t)$ $B_4^4(t)=t^4$

- **Wang-Ball curve**

The two surfaces were used using Wang-Ball curve to create new calculations for evaluating parametric surfaces, and the results show that these calculations are more powerful than the de Casteljau computation [15]. Thus, Wang Ball curve [16] can be defined for $0 \le t \le 1$ as in equation (3).

$$W(t)=\sum_{i=0}^{n}V_iW_i^n(t) \tag{3}$$

where V_i are control points and $W_i^n(t)$ are the Wang-Ball basis functions for an even and odd degree number. For even value of n, the Wang-Ball basis function is defined as equation (4).

$$W_i^n(t)=\begin{cases}(1-t)^2w^i & 0\le i\le \dfrac{n}{2}-1\\ w^{\frac{n}{2}} & i=\dfrac{n}{2}\\ t^2w^{n-i} & \dfrac{n}{2}+1\le i\le n\end{cases} \tag{4}$$

For odd value of n, the Wang-Ball basis function is defined as equation (5).

$$W_i^n(t)=\begin{cases}(1-t)^2 w^i & 0\le i\le \frac{n-3}{2}\\ (1-t)w^{\frac{n-1}{2}} & i=\frac{n-1}{2}\\ tw^{\frac{n-1}{2}} & i=\frac{n+1}{2}\\ t^2 w^{n-i} & \frac{n+3}{2}\le i\le n\end{cases} \tag{5}$$

- **Said-Ball curve**

Different kinds of structured matrices that measured to be a positive number of matrices were measured in Said-Ball, a numerical computing with a positive matrix in numerical linear.A Said-Ball is a generalised ball basis with arbitrary odd and even degrees.The calculations' outcomes are shown in Equations (6) and (7).

Even number :

$$S_i^n(t)=\begin{cases}\binom{\frac{n}{2}+i}{i} t^i(1-t)^{\frac{n}{2}+1} & 0\le i\le \frac{n}{2}-1\\ \binom{n}{\frac{n}{2}} t^{\frac{n}{2}}(1-t)^{\frac{n}{2}} & i=\frac{n}{2}\\ \binom{\frac{n}{2}+n-i}{n-i} t^{\frac{n}{2}+1}(1-t)^{n-i} & \frac{n}{2}+1\le i\le n\end{cases} \tag{6}$$

Odd number:

$$S_i^n(t)=\begin{cases}\binom{\frac{n-1}{2}+i}{i} t^i(1-t)^{\frac{n}{2}+1} & 0\le i\le \frac{n-1}{2}\\ \binom{\frac{n-1}{2}+n-i}{n-i} t^{\frac{n+1}{2}}(1-t)^{n-i} & \frac{n+1}{2}\le i\le n\end{cases} \tag{7}$$

4. Results and Discussion

4.1 Comparison for each degree of curve

The comparison for each degree was presented by using a “nun” character of the “Aamin” Calligraphy.

- **Degree 2**

Figure 2 depicts a Bezier, Wang-Ball, and Said-ball curve with a degree of 2. For the "nun" alphabet, all three curves created the same image. This demonstrates that all three curves of degree 2 have similar forms.

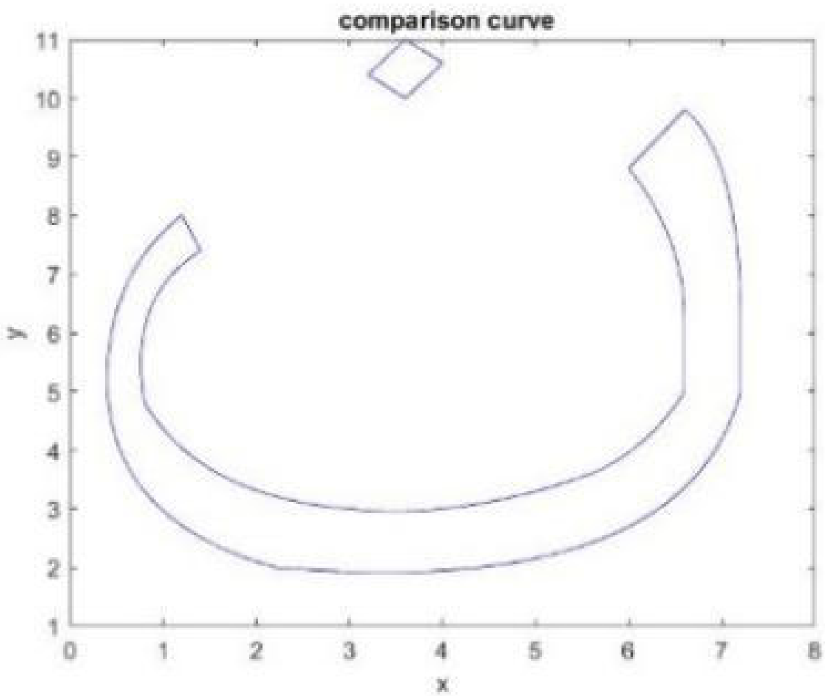


Figure 2. Combination “Aamin” calligraphy for degree 2

- **Degree 3**

The "nun" alphabet was created for degree 3 as in Figure 3. There was a slight variation between the Bezier curve with Wang-Ball and the Said-Ball curves. Compared to the **two** curves that generated the same image for "nun" alphabet, the curve of "nun" alphabet for Bezier curve (purple color) produced a smoother and nicer curve.

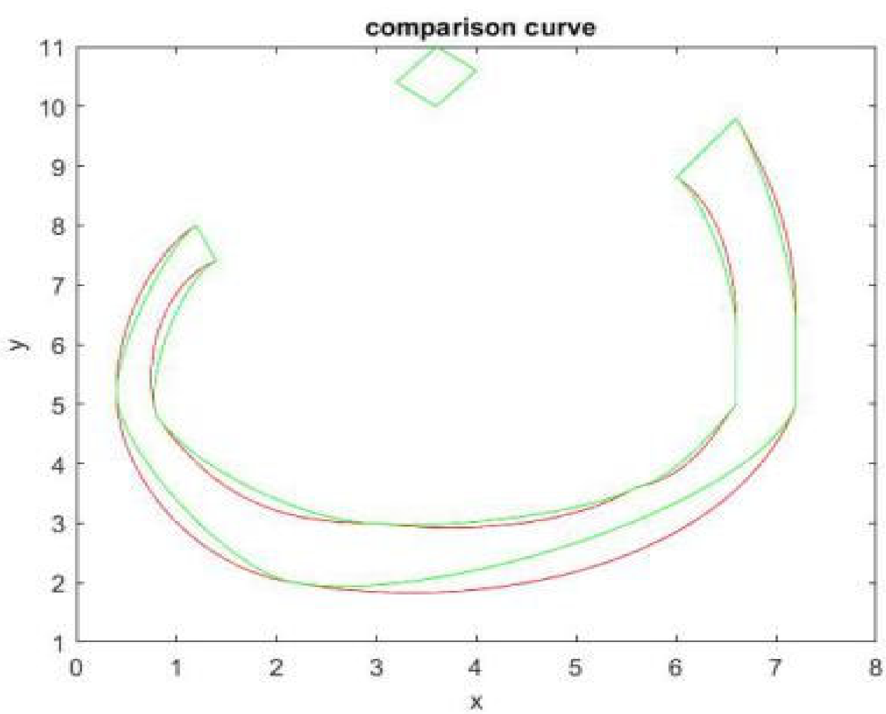


Figure 3. Combination “Aamin” calligraphy for degree 3

- **Degree 4**

Figure 4 shows that the Bezier and Said-Ball curves created the identical image of the "nun" letters, however the Wang-Ball curve produced discrepancies. Compared to Bezier and Said-Ball curves, Wang-Ball curves (blue color) appeared to have a better and smoother shape.

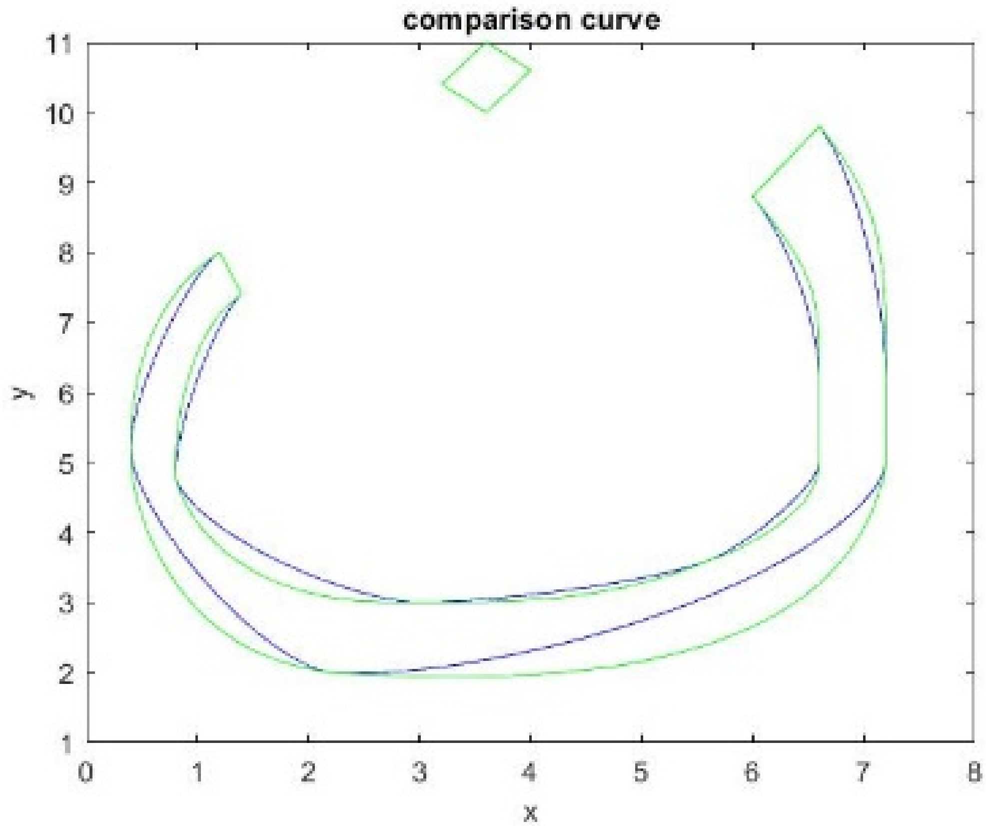
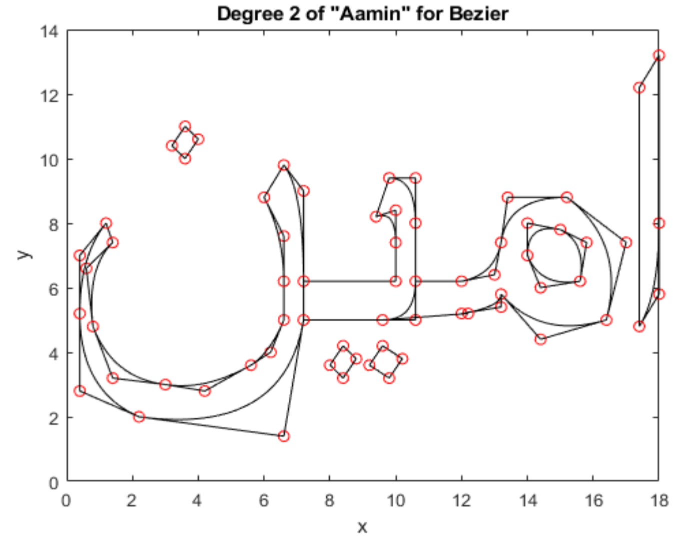
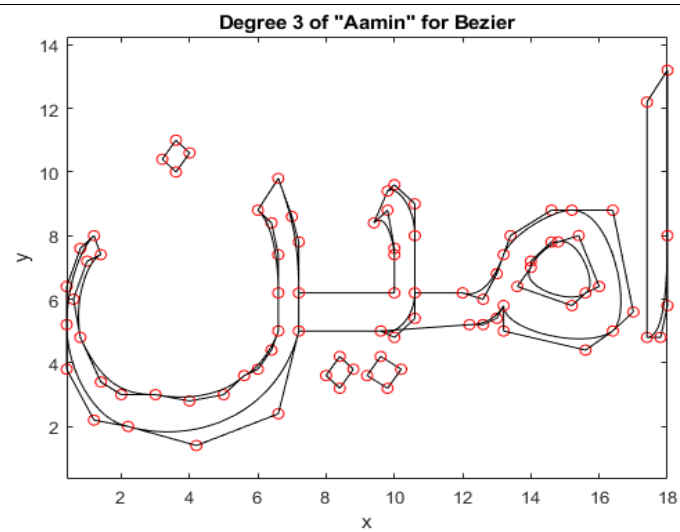
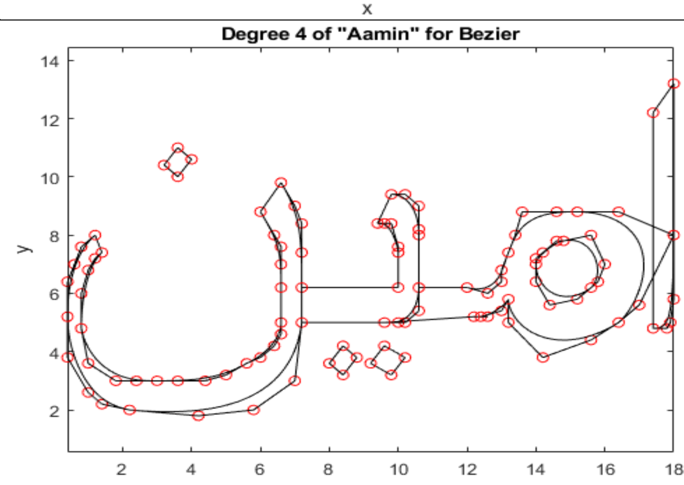
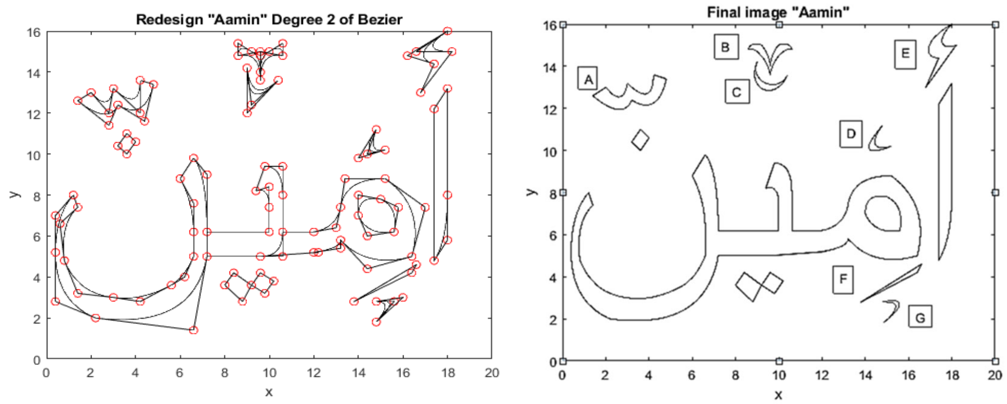


Figure 4. Combination “Aamin” calligraphy for degree 4

The calligraphy "Aamin" inside a control polygon for degrees 2, 3, and 4 are presented in Table 2 run in the MATLAB software. The Bezier, Wang-Ball and Said-Ball curves were combined for the final image. As shown in the diagram at Figure 5, a curve from the Bezier curve degree **2** for the object **A** has been selection. Then we choose the Wang-Ball curve of degree 3 for the objects **B, C,** and **E**. The Said-Ball curve of degree **3** is used for the objects **D** and **F**. There was degree **1** for item **F** thus it was a straight line. Finally, a curve from a Bezier curve of degree **3** to create the object **G** has been selected. Figure 5 shows the final redesign of "Aamin" calligraphy with and without the control polygon.

Table 2. Comparison of “Aamin” calligraphy for each degree of curves with control polygon

Degree	“Aamin” calligraphy with control polygon
2	
3	
4	



(a) with control polygon (b) without control polygon

Figure 5. Final Redesign “Aamin” calligraphy

4.2 Computation time for each degree of curve

The following Table 3 shows the result of total computation time for redesign “Aamin” calligraphy of Bezier curve, Wang-ball curve and Said-Ball curve. The total number of curves for all curves in all degree elevation did not affect other variables as the total value is remain constant. As the total number of control point increase, the total computation time also increase. The number of degree elevation has affected the total number of curves and total computation time of redesign “Aamin” calligraphy for all methods.

Table 3. Comparison of the Computation Time for Redesign “Aamin” Calligraphy

Total	Number of Curves for	Number of Control Points	Computation time of Bezier curve (sec)	Computation time of Wang-Ball curve (sec)	Computation time of Said-Ball curve (sec)
Degree 2	37	110	1.48	1.22	1.50
Degree 3	37	148	1.52	1.37	1.87
Degree 4	37	186	2.50	2.61	2.80

The result obtained from the research finding are the computation time of the redesign “Aamin” calligraphy by all curve. The redesign “Aamin” calligraphy Bezier curve computes the best time compared to Wang-Ball and Said-Ball curve. The computation time for the degree 2, degree 3 and degree 4 are 1.48 seconds, 1.52 seconds and 2.50 seconds respectively. The higher the degree elevation, the longer the computation time for the redesign "Aamin" calligraphy.

5. Conclusion

The comparison of the Bezier, Wang-ball, and Said-Ball curve has been the focused of this study. The "Aamin" phrase has been redesigned in Arabic calligraphy based on three curves to be evaluated. The best curve was determined between the best computation time for all curves. The computation time was also affected by the varied degrees of elevation. However, the computation time can be also determined by the performance of the device processor. This research provides a fundamental design and empirical findings that can further be extended to be replicated in a more complex of Arabic Calligraphics.

Acknowledgements

This work is part of a research project of final year student of Faculty of Computer and Mathematical Sciences of Universiti Teknologi Mara (UiTM) Negeri Sembilan branch supported by the research grant by Universiti Teknologi Mara (UiTM).

Conflict of Interest

The authors declare no conflict of interest in the subject matter or materials discussed in this manuscript.

References

[1] V. Guillaume, G. Valerie and B. Marie, "Cubic bézier local path planner for nonholonomic feasible and comfortable path generation," in *Proc. IEEE ICRA*, Xian, China, pp. 1–7, 2021.

[2] C. Vincent, G. Celine, L. Eva, P. Clair, and R. Magali, "Curved interface reconstruction for 2d compressible multi-material flflows," ESAIM: *Proceedings and Surveys*, vol. 67, pp. 178–190, 2020.

[3] Y. Norimasa and S. Takafumi, "Planar curves based on explicit bézier curvature functions," *Computer-Aided Design and Applications*, vol. 17, no. 1, pp. 77–87, 2020.

[4] J. Read, "Animating the real: Illusions, musicality and the live dancing body," *The International Journal of Screendance*, vol. 11, pp. 59–75, 2020.

[5] G. Mariana-Daniela and A. Emilio, "Implications of virtual reality in arts education: Research analysis in the context of higher education," *Education Sciences*, vol. 10, no. 225, pp. 1–19, 2020.

[6] O. Ismail," A matrix Method for Reparametrization of Interval SB Curves on Rectangular Domain",*International Journal of Video&Image Processing and Network Security IJVIPNS-IJENS* ,Vol:15 No:01 ,2015.

[7] A. Saaban, A. Kherd, A.F. Jameel, H. Akhadkulov and F.M. Alipiah, "Image enlargement using biharmonic Said-Ball surface", *Journal of Physics: Conference Series*, 890, 012086. doi:10.1088/1742-6596/890/1/012086,2017.

[8] S. A. Abdul Karim & A. Saaban,"Shape preserving interpolation using rational cubic ball function and its application in image interpolation", *Mathematical Problems in Engineering*, 2017.

[9] M.A. Duaa, H. Abd.Rahman and Marni N.,"Islamic Art and Language as a Source of Inspiration Leading to Traditional Arabic Calligraphy Art", *UMRAN International Journal of Islamic and Civilizational Studies*, *03*, 33–45,2019.

[10] M. H. Kurfi, "Hausa Calligraphic and Decorative Traditions of Northern Nigeria: From the Sacred to the Social", *Islamic Africa*, *8*(1–2), 13–42. https://doi.org/10.1163/21540993-00801003,2017.

[11] Abdul Kadir N.A, Nik Dahalan N.N. and J. Norsaeidah, "Seni dalam Islam: Kajian Khusus Terhadap Seni Ukir. *E-Journal of Islamic Thought and Understanding"*, *1*(January), 1–15,2018.

[12] B. Zidan, "The Concept and Utilization of Swastika 'Hooked Cross' on Islamic Artefacts", *Journal of the General Union of Arab Archaeologists*, *5*(1), 1–26. https://doi.org/10.21608/jguaa2.2020.18018.102,2020.

[13] Y. Ayse, T. Tunahan and O. Gozde, "On geometry of rational bezier curves," *Honam Mathematical Journal*, vol. 43, no. 1, pp. 88–99, 2021.

[14] V. Peter, A. Richard and A. Olabisi, "Solution of systems of disjoint Fredholm–Volterra integro-differential equations using bezier control points," *Science World Jour*nal, vol. 15, no. 4, pp. 25–40, 2020.

[15] B. Amir, P. Edouard and S. Shoham, "The cyclic block conditional gradient method for convex optimization problems," *SIAM Journal on Optimization*, vol. 25, no. 4, pp. 2024–2049, 2015.

[16] A. Al-Haboobi and H. Al-Haboobi,"Bezier Curve Extraction and Compression from Fingerprints Using New Method", In *2021 International Conference on Communication & Information Technology (ICICT)* (pp. 55-61). IEEE,2021.

[17] S. Maqsood, M. Abbas, K.T.Miura, A. Majeed and A. Iqbal,"Geometric modeling and applications of generalized blended trigonometric Bézier curves with shape parameters", *Advances in difference equations*, *2020*(1), 1-18,2020.

[18] A. Vinayak,M.A. Zakaria, K. Baarath and A.P.A. Majeed," A novel Bezier curve control point search algorithm for autonomous navigation using N-order polynomial search with boundary conditions", In *2021 IEEE International Intelligent Transportation Systems Conference (ITSC)* (pp. 3884-3889). IEEE,2021.

[19] N.Dejdumrong, H.N. Phien, H. le Tien, and K.M. Lay, "Rational Wang Ball curves", *International Journal of Mathematical Education in Science and Technology*, 32(4), 565-584, 2001.

[20] S. A. Aljunid, Z. Abu Hasan, Z.R. Yahya, N.A. Rusdi, N. Roslan, M.A.A Mohd Salleh, K. N. F. Ku Azir, "Curve Reconstruction In Different Cubic Functions Using Differential Evolution,"

MATEC Web of Conferences, 150, 06030. doi:10.1051/matecconf/201815006030,2018.
[21] A. Saaban, A. Kherd, A.F. Jameel, H. Akhadkulov and F.M. Alipiah, "Image enlargement using biharmonic Said-Ball surface", In *Journal of Physics: Conference Series* (Vol. 890, No. 1, p. 012086). IOP Publishing,2017.
[22] W. Zelong, L. Mengyuan, H. Riichi and M. Zenichiro, "Comparison between expert and beginner on calligraphy letters", *Procedia Manufacturing 3*, 495-502,2015.
[23] H. Yang, J. Lu and H. Lee, "A Bezier curve-based approach to shape description for Chinese calligraphy characters", *Proceedings of Sixth International Conference on Document Analysis and Recognition*, 276-280, 2001.
[24] Z. Wang, M. Liao, & Z. Maekawa, "A study on quantitative evaluation of calligraphy characters", *Computer Technology and Application*, 2016(7), 103-122, 2016.
[25] F.A. Sohel,G.C. Karmakar, L. Dooley & M. Bennamoun, "University ' s repository of research publications and other research outputs :A Bezier curve-based generic shape encoder",2010.
[26] S. M.Hu, G. Z. Wang & T. G. Jin, "Properties of two types of generalized Ball curves", *Computer-Aided Design*, 28(2), 125-133,1996.

Biography of all authors

Picture	Biography	Authorship contribution
	Noorehan Awang is a senior lecturer in Universiti Teknologi MARA Negeri Sembilan. Received Master degree from Universiti Sains Malaysia (USM) in 2009 in the field of Computer Aided Geometric Design (CAGD). Her research interest include the mathematical modeling of curve and surfaces.	Design the research work and drafting article
	Fatin Najihah Ghazali did her bachelors degree from School of Mathematical studies, Universiti Teknologi MARA Negeri Sembilan in 2020. Currently, she was working as QA/QC Executive at Econpile (M) Sdn Bhd.	Data collection, data analysis and interpretation
	Siti Sarah Zainuddin did her bachelors degree from School of Mathematical studies, Universiti Teknologi MARA Negeri Sembilan in 2020. Currently, she was working as Admin Assistant at Medic Care Services Sdn. Bhd.	Data collection, data analysis and interpretation