Reconstruction of Arabic Calligraphy by using Wang-Ball Curves

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Introduction

The Wang-Ball curve conveniently can be used in applications in Computer-aided design (CAD) domain such as image extraction, profile approximation, fairing, smoothing and modelization. Rational Wang-ball which is derived from non-rational Wang-ball curves, where it has been proven that a rational Wang-ball curve is a rational Bezier curve of the same degree and vice versa. A recursive algorithm for plotting rational Bezier and Wang-ball is obtained by the de Casteljau and Wang algorithm using homogeneous coordinates and an efficient algorithm for evaluating a rational Wang-ball curve is attained and has a linear time complexity (Dejdumrong et al., 2001). Arabic calligraphy was initially an instrument for correspondence, yet with time, it started to be utilized in engineering, adornment and other structure. It is one of the art phenomena in the history of the revitalization of traditional art in the contemporary world. The outline of the calligraphy, mostly Arabic outline, was usually in quadratic and cubic degree. Therefore, the reconstruction of arabic font for degrees more than third degree for Wang-Ball curve was taken into consideration. The character of 'Aamin' in Arabic font was used in this research as shown in Figure 1.

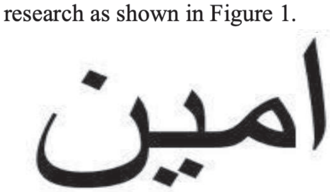


Figure 1: 'Aamin' Arabic calligraphy

Methodology

As stated by Hu et al. (1996), the Wang-Ball curve is defined as in (1).

$$W(t) = \sum_{i=0}^{n} W_i^n(t) V_i,\ 0 \le t \le 1 \qquad (1)$$

where V_i are control points and $W_i^n(t)$ are the Wang-Ball basis functions for an even and odd degree number, which are defined as in Equation 2 and 3 below:

For even value of $n = 2, 4$, the Wang-Ball basis function is defined as:

$$W_i^n(t) = \{(1-t)^2 W^i, 0 \le i \le \frac{n}{2} - 1\ W^{\frac{n}{2}}, i = \frac{n}{2}\ t^2 W^{n-i}, \frac{n}{2} + 1 \le i \le n$$

(2)

For odd value of $n = 3, 5$, the Wang-Ball basis function is defined as:

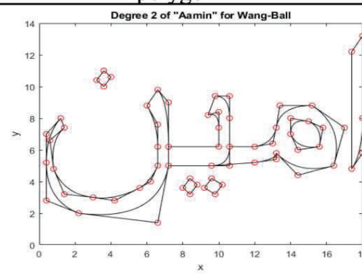
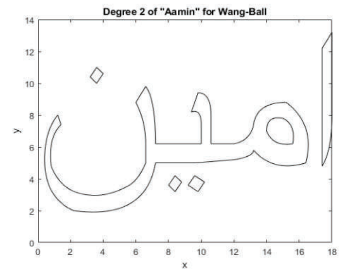
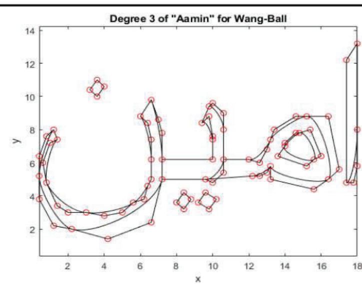
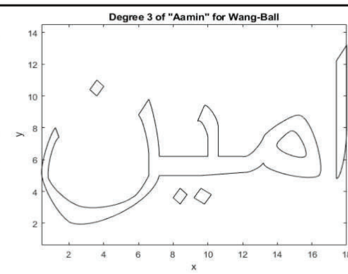
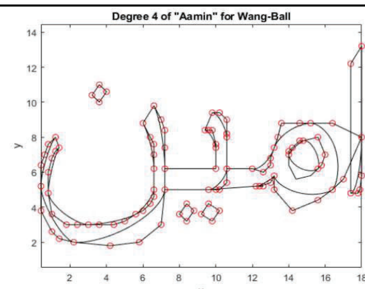
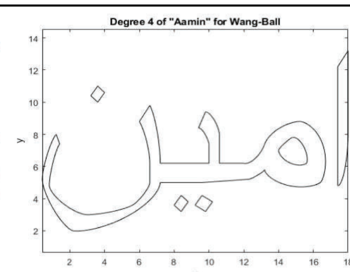
$$W_i^n(t) = \{(1-t)^2 W^i, 0 \le i \le \frac{n-3}{2}\ (1-t) W^{\frac{n-1}{2}}, i = \frac{n-1}{2}\ t W^{\frac{n-1}{2}}, i = \frac{n+1}{2}\ t^2 W^{n-i}, \frac{n+3}{2} \le i \le n$$

(3)

Results and Discussion

Wang-Ball curve was produced by using MATLAB software for different basic functions (even and odd degree). Table 1 shows the result of full "Aamin" calligraphy using Wang-Ball curve with and without control polygon.

Table 1: Comparison of "Aamin" Calligraphy for different degree elevation by using Wang-Ball curve

Degree	"Aamin" Calligraphy with control polygon	"Aamin" Calligraphy without control polygon
2		
3		
4		

The computation time of "Aamin" calligraphy by using Wang Ball curve was shown in Table 2. The similar number of curves was used for different degrees and this produced computation time shown by MATLAB software for degree 2, 3 and 4 as 1.22 seconds, 1.37 seconds and 2.61 seconds respectively. From these results, it shows that the higher the degree elevation, the longer the computation time for the redesign of "Aamin" calligraphy.

Table 2: Comparison Between the Number of Control Points, Number of Curves and Computation Time for "Aamin" Calligraphy using Wang-Ball Curve

Total Degree	Total Number of Curves	Total Number of Control Points	Computation time(sec)
2	37	110	1.22
3	37	148	1.37
4	37	186	2.61

References

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

Hu, S. M., Wang, G. Z., & Jin, T. G. (1996). Properties of two types of generalized Ball curves. Computer-Aided Design, 28(2), 125-133.