UNIVERSITI TEKNOLOGI MARA

JOHOR INTERNATIONAL INNOVATION, INVENTION COMPETITION AND SYMPOSIUM

PROCEEDINGS OF JOHOR INTERNATIONAL INNOVATION INVENTION COMPETITION AND SYMPOSIUM 2024 (JIIICaS 2024)

"Flourish and Nurturing Sustainable Innovation for a Prosperous Nation"

JOHOR INTERNATIONAL INNOVATION, INVENTION COMPETITION AND SYMPOSIUM

Editorial Board

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Preface

In the name of Allah, the Almighty who gives us the enlightenment, the truth, the knowledge and with regards to Prophet Muhammad (peace be upon him) for guiding us to the straight path. We thank to Allah for giving us guidance and strength to write this e-book.

This e-book compiles the extended abstracts that submitted to Johor International Innovation Invention Competition and Symposium 2024 (JIIICaS2024), where JIIICaS2024 is a virtual platform for all creative minds to share and present their invention and innovation. Each abstract gives a brief background on the innovation or project.

We hope that this e-book will help the readers to get to know the innovation done by the students and get some ideas to develop future innovation products.

Foreword Rector

Assalamualaikum warahmatullahi Wabarakatuh,
Salam Sejahtera, Salam Malaysia MADANI and Salam UiTM Dihatiku.

In the name of Allah, the Most Gracious, the Most Merciful.

It is a great honor to welcome you to the Johor International Innovation, Invention, Competition, and Symposium 2024 (JIIICaS 2024). This event connects various disciplines, focusing on education and engaging educators, students, researchers, and innovators from all walks of life.

Innovation is not just about ideas; it demands perseverance, creativity, and determination to turn those ideas into reality. The remarkable projects showcased today highlight the dedication and spirit of all participants. Initiatives like this not only explore new technologies but also cultivate skills and leadership among our youth. At Universiti Teknologi MARA (UiTM) Johor Branch, we are fully committed to fostering a dynamic culture of innovation, promoting the commercialization of new products, and encouraging meaningful collaborations with industry and society.

As we celebrate this event, I would like to extend my heartfelt gratitude to all sponsors, judges, the College of Computing, Informatics and Mathematics, UiTM Pasir Gudang Campus as the event organizer, as well as to the researchers and participants for their hard work in making this event a success. Let us continue striving for innovation and excellence. May the ideas presented today inspire us and lay the groundwork for future achievements.

Thank you.

Associate Professor Dr. Saunah Zainon
Rector
Universiti Teknologi MARA (UiTM)
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(A-ST183) AN INTERACTIVE TOOL OF QUADRATIC TRIGONOMETRIC B-SPLINE IN DESIGNING OBJECTS

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ABSTRACT

Choosing the right spline algorithm significantly influences the quality and efficiency of the design process in CAGD. Designers and engineers often face difficulties in selecting between different spline techniques due to their specific benefits and drawbacks. This research aims to bridge this gap by evaluating the performance of Quadratic Trigonometric B-Spline (QTBS) in resolving specific design issues using *Wolfram Mathematica* software. The study begins by exploring the methods employed by QTBS for two-dimensional curve, assessing their ability to generate desired shapes with supreme smoothness. The research extends into three-dimensional surface design, analysing the capabilities of QTBS in crafting three-dimensional surfaces of an object using Sweep surface method with controlled curvature and flawless continuity. The paper demonstrates the advantages and disadvantages of each approach for handling design difficulties by a thorough analysis of the mathematical models and real-world applications. By designing curves of an object, the study integrates an interactive application for both methods to demonstrates the curve behaviour by modifying the shape parameters and control points of the objects. The integration of QTBS in CAGD enhances the designer's ability to create sophisticated and accurate geometric models. The final phase of the study focuses on determining the most effective B-spline method for enhancing smoothness in both two-dimensional and three-dimensional spaces which is QTBS method.

Keywords: Quadratic Trigonometric, B-Spline, Sweep Surface, Design

1.0 INTRODUCTION

The field of Computer-Aided Geometric Design (CAGD) enables designers and engineers to generate and manipulate complex two-dimensional curves and three-dimensional surfaces with precision and ease. Each spline technique has distinct advantages and drawbacks, making it challenging to select the optimal method for achieving the desired levels of smoothness and control. This study investigates the effectiveness of Quadratic Trigonometric B-Splines (QTBS) in addressing these specific challenges.
The selection of an appropriate spline algorithm is critical in CAGD, as it directly impacts the overall quality and efficiency of the design process (Lim, 2023). Choosing among various spline techniques, such as QTBS, can be a daunting task for designers and engineers due to the unique benefits and limitations of each method (Amini & Abbas, 2022, Samreen et al., 2022). This study aims to address this gap by evaluating the capabilities of QTBS in overcoming specific design challenges.

This research delves into the complex realm of two-dimensional curve creation, exploring the methods employed by QTBS. The investigation analyzes the effectiveness of QTBS in generating the desired shapes and achieving supreme smoothness (Abbas et al., 2021). By deconstructing the mathematical foundations of QTBS and comparing its practical applications, the study provides a comprehensive understanding of the viability of this approach in handling various two-dimensional design challenges.

In the context of three-dimensional design, this study examines the process of creating intricate surfaces using QTBS. It investigates the ability of QTBS to design aesthetically pleasing and functionally robust geometries with controlled curvature and seamless surface continuity (Choi et al., 2020). Through a thorough analysis of their mathematical models and practical demonstrations, the strengths and weaknesses of QTBS in addressing a range of three-dimensional design problems are explored.

2.0 OBJECTIVE

According to the problem statement, there are three objectives that must be met:

i. to design a two-dimensional curve for an object by using Quadratic Trigonometric B-Spline (QTBS) and Cubic B-Spline (CBS),
ii. to design three-dimensional surfaces for an object by using sweep surface method
iii. to identify the most effective method that enhances the smoothness of curves and surfaces.

3.0 METHODOLOGY

3.1 Quadratic Trigonometric B-Splines

Quadratic Trigonometric B-Splines are a type of spline function used in computer graphics and geometric modelling. They are defined using trigonometric functions which provide smoother curves compared to polynomial splines. QTBS are particularly useful in designing objects where smooth transitions and continuity are important. QTBS offer smoother transitions due to the inherent properties of trigonometric functions. However, QTBS are computationally more complex due to the use of trigonometric functions making them more challenging to implement and less flexible in terms of shape approximation.

This section contains the definitions and characteristics of the basis functions for the QTBS. Hussain et al. (2017) defined the piecewise Quadratic Trigonometric Spline function $T(t)$ with shape parameters $\alpha, \beta \epsilon [0, \pi]$ over sub interval $t \in [t_i, t_{i+1}], i = 0,1, \dots, n$. The variable $Q_i, i = 0,1,2,3$ are the co-efficient of interpolation. are as follows:

$$T_i(t) = \sum_{i=0}^{3} A_i\,(\theta, \alpha, \beta)\,Q_i \qquad (1)$$

where

$$0 \le \theta \le \frac{\pi}{2}, \theta(t) = \left(\frac{t - t_i}{h_i}\right)\frac{\pi}{2}, h_i = t_{i+1} - t_i$$

Now the quadratic trigonometric are rewrite as:

$$T_i(t) = A_0(\theta,\alpha,\beta)F_i + A_1(\theta,\alpha,\beta)V_i + A_2(\theta,\alpha,\beta)W_i + A_3(\theta,\alpha,\beta)F_{i+1}\ , \qquad (2)$$

where

$$A_0(\theta,\alpha,\beta) = (1-\sin\theta)(1-\alpha\sin\theta)\ ,$$
$$A_1(\theta,\alpha,\beta) = (1+\alpha)\sin\theta\,(1-\sin\theta)\ ,$$
$$A_2(\theta,\alpha,\beta) = (1+\beta)\cos\theta\,(1-\cos\theta)\ ,$$
$$A_3\ ,(\theta,\alpha,\beta) = (1-\cos\theta)(1-\beta\cos\theta)\ .$$

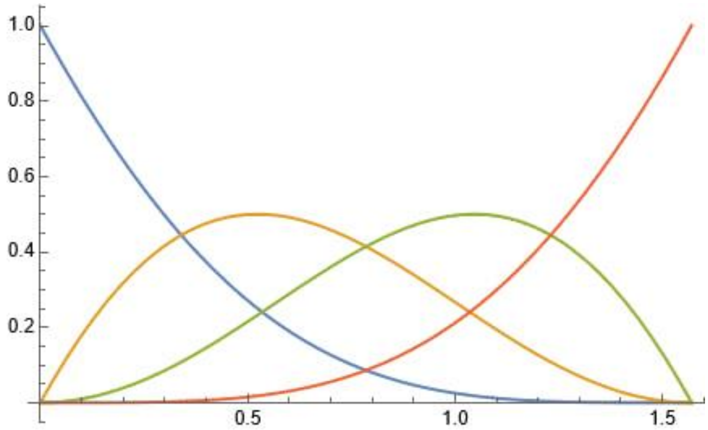

Figure 1: Graph of Quadratic Trigonometric B-Spline basis function

QTBS basis function as shows in figure 1 combines trigonometric and polynomial components to form smooth curves. These splines are defined piecewise by quadratic polynomials that include trigonometric terms, such as sine and cosine functions. The primary advantage of this approach is its ability to capture oscillatory behaviour more naturally than purely polynomial splines, making them particularly useful in applications where periodic or wave-like patterns need to be modelled. QTBS ensure continuity and smoothness at the joints of the spline segments, providing a flexible yet precise way to approximate complex shapes and functions.

3.2 Sweep Surface Method

Creating a three-dimensional surface using the swept surface method with QTBS involves defining a profile curve and a trajectory curve. The profile curve is a two-dimensional shape described using QTBS, constructed from a set of control points and an appropriate knot vector, which ensures the desired level of smoothness and continuity. The trajectory curve is a three-dimensional path, also defined by control points and a knot vector, which dictates the movement of the profile curve through space. To generate the swept surface, both the profile and the trajectory curves are parameterize, denoted by parameters u and v, respectively as follows:

$$S(u,v) = C(u)\cdot T(v) \qquad (3)$$

where $S(u,v)$ is the point on the surface, $C(u)$ is the point on the profile curve at parameter u and $T(v)$ is the transformation matrix at parameter v that was derived from the trajectory curve

4.0 RESULTS

The curves of the table lamp created using QTBS method as show in figure 2. In the interactive application, users are presented with a graphical interface where they can adjust the shape parameter and certain control point through a slider and input box. As the shape parameter and the control points changes, the QTBS curve is recalculated and displayed in real-time. This dynamic interaction helps users visualize the impact of the shape parameter on the curve's form. The applications are designed with simple, easy-to-understand interfaces that allow users to quickly learn how to manipulate control points to shape the curve.

Figure 2: Interactive Application of two-dimensional curve using QTBS

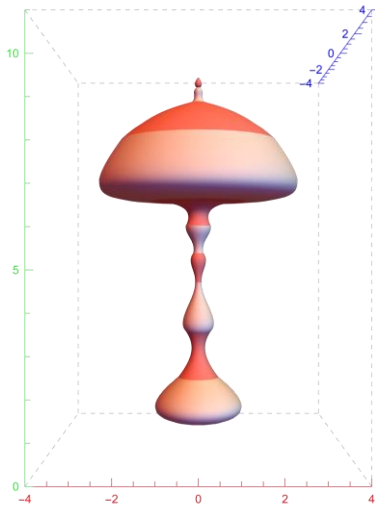

Figure 3: Three-dimensional curve of table lamp using QTBS with shape parameter $\alpha, \beta = \frac{\pi}{4}$

Figure 3 shows the result of the table lamp's surface using QTBS and sweep surface method. The QTBS surface appointed is created using shape parameter $\alpha = \frac{\pi}{4}$ and $\beta = \frac{\pi}{4}$ which create better smoothness compared to other shape parameters. It also produces shape that are closer to the actual image of the table lamp.

5.0 CONCLUSION

Designing curves and shapes using Quadratic Trigonometric B-Spline (QTBS) methods is successfully implemented and evaluated, resulting in smooth and aesthetically pleasing two-dimensional curves. The analysis demonstrated that the QTBS can produce various curves with different shape parameters build nearly identical curve with QTBS method using shape parameter $\alpha = \frac{\pi}{4}$ and $\beta = \frac{\pi}{4}$.

Furthermore, QTBS is able to create smooth and continuous three-dimensional surfaces of the table lamp. The methods showed fulfilling performance in capturing the intricate details and complex geometries of the objects. The ability of QTBS to maintain a high level of accuracy and smoothness in three-dimensional designs underscores its potential for advanced surface modelling applications.

Moreover, the integration of interactive applications in *Mathematica* not only enhances the design process but also opens avenues for future research and development. These tools can be expanded to include more complex modelling tasks, potentially incorporating additional parameters and advanced features to further enhance their utility and effectiveness. These tools provide immediate visual feedback, allowing users to see the effects of their changes instantly. This helps in making quick adjustments and achieving the desired shape more efficiently.

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