



UNIVERSITI
TEKNOLOGI
MARA

ISETC2025

2ND INTERNATIONAL SCIENCE,
ENGINEERING AND TECHNOLOGY
COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A
SUSTAINABLE WORLD

ORGANIZED BY:
FACULTY OF APPLIED SCIENCES
UNIVERSITI TEKNOLOGI MARA
PERAK BRANCH, TAPAH CAMPUS
MALAYSIA

CO-ORGANIZED BY:



**2nd International Science, Engineering and Technology Colloquium
(ISETC 2025)**

Faculty of Applied Sciences,
Universiti Teknologi MARA,
Perak Branch, Tapah Campus,
35400 Tapah Road, Perak, Malaysia.

Colloquium date: 9th July 2025

Publication date: 9th September 2025

Proceedings of Extended Abstracts

EDITORS

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

Ms. Rozaina Saleh

e-ISBN: 978-629-97630-5-5

Copyright © 2025 ISETC

Published by Faculty of Applied Sciences, Universiti Teknologi MARA,
Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, Malaysia.

PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob

Dr. Saiyidah Nafisah Hashim

Ms. Lili Widarti Zainuddin

Ms. Nurul Nazwa Mohammad

Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

SURFACE RECONSTRUCTION OF A CT SCAN IMAGES USING G^1 CUBIC TRIGONOMETRIC TRIANGULAR SPLINE

Muhammad Syawal Abd Halim¹, Normi Abdul Hadi^{2*}

¹*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA Perak Branch, Tapah Campus,
Tapah Road 35400, Perak, Malaysia*

²*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA,
Shah Alam 40450, Selangor, Malaysia*

**Corresponding author: normi683@uitm.edu.my*

Abstract: Digitization of an object from visual to data point will help researchers manipulate the data for further use – particularly in reconstructing a surface. The use of trigonometric function to generate a triangular surface are able to offer smooth surface with flexibility because it has the advantages of derivation and cyclability. This study extract control points from CT scan images of a human head by parameterizing the image boundary. The control points are then triangulated and the G^1 cubic trigonometric triangular spline with rational basis functions are then applied to construct the surface. The G^1 continuity were used for smooth surface with rational basis functions that closer to the control points and has smaller parameter range $[0, 1]$ and the results are illustrated in this study.

Keywords: *Surface reconstruction, CT-scan, cubic trigonometric triangular, G^1 continuity*

INTRODUCTION

Surface interpolation from 3-dimensional data points is a fundamental problem in Computer-Aided Geometric Design (CAGD). It began by acquiring the data points from either the point cloud data, structured data, or digitization from visual data. Reconstruction from point cloud is more challenging since the data is unstructured. Meanwhile, structured data is often more accurate and easier to process due to its organized nature (Hadi, 2014).

The early development of a system that design curves and surfaces was led by a young mathematician named Paul de Faget de Casteljau. He used Bernstein polynomials to define curves and surfaces at an early stage which is now known as the de Casteljau algorithm (Farin, 2002). He used control polygon to construct a curve, where the changes of the control polygon will affect its shape.

Computer Aided Design (CAD) is being continuously studied and improved along with technological advancement. Trigonometric functions have been used to plot curves and extended to rectangular surfaces. Only a few focus on triangular surface. This study illustrates surface reconstruction from multi-slice CT scan images to 3-dimensional data points of a human head using MATLAB software. The data were triangulated, and the barycentric coordinates were calculated for control points. G^1 continuity was applied into the data, and the surface was generated.

MATERIALS AND METHODS

This study used CT scan images, consist of 50 layers of a human head taken from (Hadi, 2012). From each of the layer, 64 points will be extracted as a control point to the surface interpolation. The process of extraction from CT scan image is illustrated in Figure 1 below.

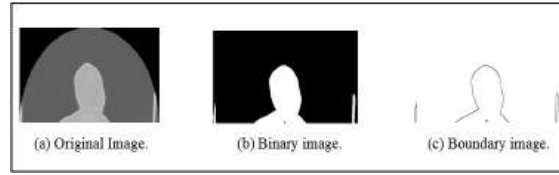


Figure 1. Process of extracting boundary data points

The original image is illustrated in Figure 1 (a). It is then converted to a binary form where it contains only two intensity values, black and white as in Figure 1 (b) using equation (1). Conversion consists of a threshold value T set and $L(x,y)$ is the original intensity pixel with (x,y) coordinates. The intensity after conversion is mathematically expressed as,

$$g(x,y) = \begin{cases} 1 & \text{for } L(x,y) \geq T \\ 0 & \text{for } L(x,y) < T \end{cases} \quad (1)$$

The Boundary of the image needs to be extracted by tracing among the white pixels as shown in Figure 1 (c) above. From the boundary image, 64 data points were extracted. These steps are repeated for all layers of a human head with total number of 3,200 data points in 3D space.

This study uses barycentric coordinate system to express the position of a point within a triangle given the triangle's vertex (Capitán, 2015). Given V_1 , V_2 and V_3 as vertices, any point P can be represented as,

$$P = \lambda_1 V_1 + \lambda_2 V_2 + \lambda_3 V_3 \quad (2)$$

Where $\lambda_1 + \lambda_2 + \lambda_3 = 1$ and each λ_i is the barycentric coordinate corresponding to a vertex.

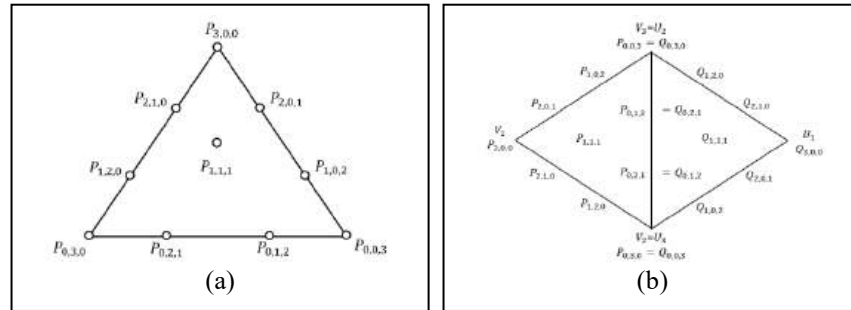


Figure 2. (a) Control Points in Triangular Domain. (b) Continuity State of Two Triangles

The ten points as shown in Figure 2(a) need to be organized because it will be used as control points to reconstruct surface. The control points arrangement must be aligned with the basis function of surface interpolation for smooth computation. All three vertices are defined as,

$$P_{3,0,0} = V_1, P_{0,3,0} = V_2, P_{0,0,3} = V_3 \quad (3)$$

Another seven sets of $(\lambda_1, \lambda_2, \lambda_3)$ such that $\lambda_1 + \lambda_2 + \lambda_3 = 1$ and $\lambda_i \geq 0$ was constructed.

For surface interpolation, the basis was taken from (Halim, 2024). Given control points $P_{ijk} \in \mathcal{R}^3 (i, j, k \in \mathbb{N}, i + j + k = 3)$, the trigonometric patch over triangular domain is shown.

$$R(u, v, w) = \sum_{i+j+k=3} T_{i,j,k}^3(u, v, w; \lambda, \mu, \gamma) P_{i,j,k} \quad (4)$$

Where $\{T_{i,j,k}^3\} (i+j+k=3)$ are the basis functions, and $\{P_{i,j,k}\} (i+j+k=3)$ are the control points.

Let $R_1(u, v, w)$ and $R_2(u, v, w)$ be two surfaces. The equation is shown below:

$$\begin{aligned}
R_1(u, v, w) &= \sum_{i+j+k=3} T_{i,j,k}^3(u, v, w; \lambda, \mu, \gamma) P_{i,j,k} \\
R_2(u, v, w) &= \sum_{i+j+k=3} T_{i,j,k}^3(u, v, w; \lambda, \mu, \gamma) Q_{i,j,k}
\end{aligned} \tag{5}$$

For G^0 continuity, the two triangles $\Delta V_1 V_2 V_3$ and $\Delta U_1 U_2 U_3$ have a common boundary along $V_2 V_3$ and $U_2 U_3$, where $P_{0,3,0} = Q_{0,0,3}$, $P_{0,2,1} = Q_{0,1,2}$, $P_{0,1,2} = Q_{0,2,1}$ and $P_{0,0,3} = Q_{0,3,0}$.

The boundary can be written as $P_{0,j,k} = Q_{0,j,k}$, $j, k \in N, j + k = 3$, or possesses a common boundary curve $R_1(0, v, w) = R_2(0, v, w), v + w = \pi/2$.

To achieve the G^1 continuity condition are,

$$\begin{aligned}
(Q_{111} - Q_{012}) &= \alpha(P_{021} - P_{012}) + \beta(P_{111} - P_{012}) \\
(Q_{102} - Q_{003}) &= \alpha(P_{012} - P_{003}) + \beta(P_{102} - P_{003}) \\
(Q_{120} - Q_{021}) &= \alpha(P_{030} - P_{021}) + \beta(P_{120} - P_{021})
\end{aligned} \tag{6}$$

Where $\alpha = 1$ and $\beta = -1$.

Finally, the surface interpolation was analyzed to determine the RMSE and maximum error (Chai, 2015).

$$e_i = |z_i - \hat{z}_i|$$

Where z_i = Control points

$\hat{z}_i$ = Interpolated surface points

$$\begin{aligned}
\text{Max. Error} &= \max(e_i) \\
\text{RMSE} &= \sqrt{\frac{\sum_{i=1}^N (e_i)^2}{N}}
\end{aligned} \tag{7}$$

RESULTS AND DISCUSSION

Figure 3 below shows all 3,200 points in 3D space. It consist of 50 slices of CT scan images with 64 points each slice. Since the data points is in organized form, it is then triangulated structurally.

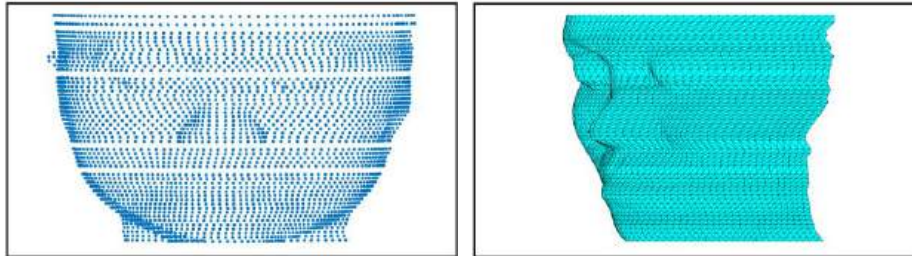


Figure 3. 3-Dimensional data points and triangulation

The basis to reconstruct surface in equation (4), and continuity in equation (6) were applied. The surface interpolation of a human head is shown in Figure 4 below.

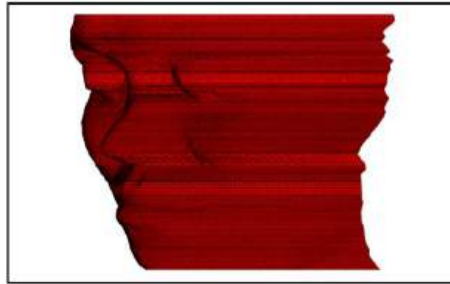


Figure 4. Interpolated Surface

Table 1 below shows the maximum error and RMSE of the interpolated surface of a human head.

Table 1. Surface Interpolation Error

Error Analysis	Shape Parameter, [0,1]	
	0	1
RMSE	0.4764	0.3926
Max. Error	4.7041	4.2199

The RMSE is 0.4764 when the shape parameter is in minimum value of 0 in the interval. When the shape parameter is increased to 1, which is the maximum value, the RMSE decreased to 0.3926. It indicates that higher value of shape parameter will have surface closer to the control points. Meanwhile, the maximum error recorded is 4.7041 when shape parameter is 0 and 4.2199 when shape parameter is 1.

CONCLUSIONS

The extraction data points from CT scan images makes it easier to process since the data is structured. This study manages to illustrate an interpolated surface of a human head using a structured 3-dimensional data as control points with G^1 cubic trigonometric triangular spline with rational basis functions. The root mean square error (RMSE) and maximum error were computed and the result indicates that the surface interpolation method used in this study are reliable. For future study, CT scan image of any part of human body can be used to analyze any deformity.

REFERENCES

- Abd Halim, M. S., Abdul Hadi, N., Nayan, A. ., & Varlamova, L. . (2024). Cubic Trigonometric Triangular Spline with Rational Basis Functions in 3-Dimensional Space. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 56(3), 170–186.
- Capitán, F. J. G. (2015). Barycentric Coordinates. *International Journal of Computer Discovered Mathematics*, 32-48.
- Chai, T., & Oceanic, N. (2015). *Root mean square error (RMSE) or mean absolute error (MAE)?—Arguments against avoiding RMSE in the literature. January 2014.*
- Farin, G. E. (2002). A History of Curves and Surfaces in CAGD. *Handbook of computer aided geometric design*, 1, 1-22.
- Hadi, N. A., Abd Halim, M. S., Ibrahim, A., Sulaiman, H., Yahya, F., & Ali, J. M. (2014, January). Dyadic Segmentation for Parallel Beta-Spline Surface Reconstruction from Multi-slice Images. In *2014 5th International Conference on Intelligent Systems, Modelling and Simulation* (pp. 524-528). IEEE.
- Hadi, N. A., Ibrahim, A., Yahya, F., & Ali, J. M. (2012). Beta-spline surface fitting to multi-slice images. *Journal of World Applied Science and Technology*, 1326-1331.



Surat kami : 700-KPK (PRP.UP.1/20/1)
Tarikh : 20 Januari 2023



Prof. Madya Dr. Nur Hisham Ibrahim
Rektor
Universiti Teknologi MARA
Cawangan Perak

Tuan,

**PERMOHONAN KELULUSAN MEMUAT NAIK PENERBITAN UiTM CAWANGAN PERAK
MELALUI REPOSITORI INSTITUSI UiTM (IR)**

Perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pihak kami ingin memohon kelulusan tuan untuk mengimbas (*digitize*) dan memuat naik semua jenis penerbitan di bawah UiTM Cawangan Perak melalui Repositori Institusi UiTM, PTAR.

3. Tujuan permohonan ini adalah bagi membolehkan akses yang lebih meluas oleh pengguna perpustakaan terhadap semua maklumat yang terkandung di dalam penerbitan melalui laman Web PTAR UiTM Cawangan Perak.

Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

Setuju.

27.1.2023

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

PROF. MADYA DR. NUR HISHAM IBRAHIM
REKTOR
UNIVERSITI TEKNOLOGI MARA
CAWANGAN PERAK
KAMPUS SERI ISKANDAR

nar