Research Article

Determining The Area of The Lake in Seksyen 7, Shah Alam by Using Discrete Least Square Interpolation Method

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Abstract: *This study implements discrete least square interpolation method, which has transformed the accurate measurement of object size and shape. Traditional methods struggled with irregularly shaped or complex objects, leading to challenges and human errors. However, the discrete least square interpolation method has improved efficiency and precision in the process. By dividing the object's surface into discrete points and utilising regression analysis, this method determines the best-fitting curve that represents the object's boundary. By successfully developing a mathematical model for calculating the area of the lake in Seksyen 7, Shah Alam, this study will provide valuable insights into the lake's characteristics and contribute to urban planning, environmental management, and recreational activities in the area.*

Keywords: discrete least square interpolation, object areas, precise measurements.

1. INTRODUCTION

Innovation in the field of measurement techniques has always played a crucial role in various industries and scientific research. One such innovation is the application of the discrete least square interpolation method for measuring the area of objects. This method has revolutionised the way of determining the size and shape of objects accurately, and providing valuable insights across numerous domains (Ibrahim, 2022).

Traditionally, measuring the area of irregularly shaped or complex objects was challenging and prone to human errors (Labibzadeh, 2016). However, with the discrete least square interpolation method, the process has become more efficient and precise. By dividing the object's surface into discrete

points and utilising regression analysis, this method determines the best-fitting curve or shape that represents the object's boundary. It offers versatility, and applicable to a wide range of objects regardless of complexity (Eason, 1978). Beyond area measurement, analysing the fitted curve provides insights into the object's curvature, symmetry, and other geometric properties, aiding in quality control, manufacturing optimization, and medical diagnostics. Technological advancements, such as 3D scanning and computer vision, enhance the method's application, ensuring precise data acquisition and faster measurements. This study will estimate the size of the area of the lake of Seksyen 7 Shah Alam more accurately using discrete least square interpolation method.

2. METHOD & MATERIAL

The material used is a map of the lake of Seksyen 7 Shah Alam. This lake has a complex shape property. The map of the lake was obtained from an online map; hence the map was transferred in the graph paper as shown in Figure 1.

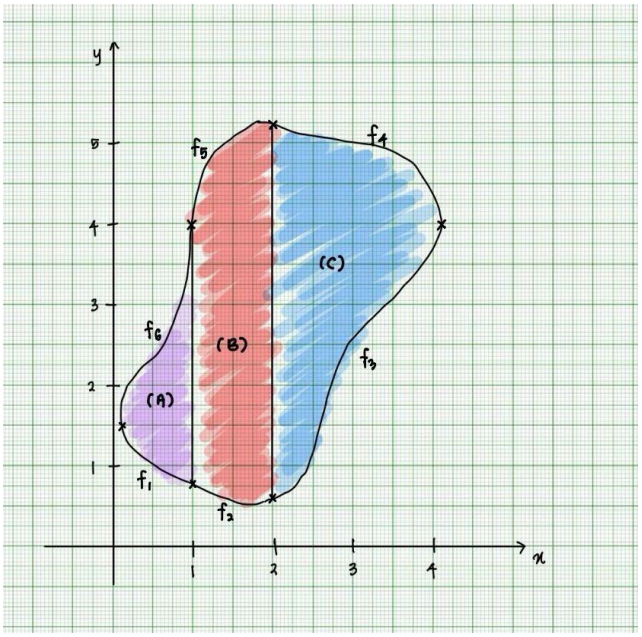

Figure 1. Map of the lake in Seksyen 7, Shah Alam.

Step 1: The graph was divided into 3 parts which are region A, B, and C as shown in Figure 1.

Step2: Points and coordinates were obtained from the graph $(x1, y1), (x2, y2), \dots, (xn, yn)$. Hence, the coordinates were calculated as $x, y, x^2, x^3, x^4, xy \; and \; x^2y$.

Step 3: The degree m of the polynomial was determined and a general expression of a polynomial was written as equation (1). In this study, $m = 2$ was used so that a quadratic equation can be obtained.

$$f(x) = a0 + a1x + a2x^2 \quad (1)$$

Step 4: The normal equations in matrix form $(m + 1) \times (m + 1)$ will be developed as in equation (2). In this study, the matrix 3 × 3 will be used.

$$\begin{bmatrix} n & \sum x & \sum x^2 \\ \sum x & \sum x^2 & \sum x^3 \\ \sum x^2 & \sum x^3 & \sum x^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{matrix} \sum y \\ \sum xy \\ \sum x^2 y \end{matrix} \quad (2)$$

Step 5: The coefficients of $a0, a1, and\ a2$ will be solved in equation (2) by using Gauss-Jordan elimination method.

Step 6: The values of $a0, a1, and\ a2$ obtained from Step 5 will be substituted in equation (1) to obtain least square functions, $f(x)$.

Step 7: The area will be calculated using equation (3) by integrating the least square function, $f(x)$ obtained in Step 6

$$\text{Area, } = \int_a^b f(x)\text{dx} \tag{3}$$

Hence, step 2 until step 7 will be repeated to calculate region A, B, and C separately. Hence, the total area of the lake will be calculated by adding all the regions.

3. FINDINGS

This report discusses the use of the discrete least square interpolation method to find the equations of the lake. The method involves a set of data points obtained from the graph paper. Data used in this project were obtained from Figure 1.

3.1 Solution

Six quadratic equations were obtained from the graph in Figure 1 which are (4), (5), (6), (7), (8) and (9) as follow.

$$f1(x) = 1.6307 - 2.0527x + 1.2368x^2 \tag{4}$$
$$f2(x) = 2.8488 - 2.8885x + 0.8830x^2 \tag{5}$$
$$f3(x) = -5.7986 + 3.7883x - 0.3426x^2 \tag{6}$$
$$f4(x) = 1.5438 + 2.8153x - 0.5436x^2 \tag{7}$$
$$f5(x) = 4.6526 + 0.9257x - 0.3310x^2 \tag{8}$$
$$f6(x) = 1.5943 + 0.6569x + 1.8559x^2 \tag{9}$$

3.2.2 Results

After inserting all the data and constructing the least square equation, the area A, B, and C, and total of the lake area were calculated.

Area (A)

$$\int_{0.1}^{1} f6\,(x)\ dx - \int_{0.1}^{1} f1\,(x)\ dx$$
$$= \int_{0.1}^{1} (1.8558\,x^2 + 0.6569\,x + 1.5943)dx - \int_{0.1}^{1} (1.2368\,x^2 - 2.0527\,x + 1.6307)dx$$
$$= 2.3780502 - 0.9083979 = 1.4696523\ unit^2$$

Area (B)

$$\int_{1}^{2} f5\,(x)\,dx - \int_{1}^{2} f2\,(x)\,dx$$
$$= \int_{1}^{2} (-0.3310\,x^2 + 0.9257\,x + 4.6526)\,dx - \int_{1}^{2} (0.8830\,x^2 - 2.8885\,x + 2.8488)\ dx$$
$$= 5.26881667 - 0.57638333 = 4.69243334\ unit^2$$

Area (C)

$$\int_{2}^{4} f4\,(x)\,dx - \int_{2}^{4} f3\,(x)\,dx$$
$$= \int_{2}^{4} (-0.5436\,x^2 + 2.8153\,x + 1.5438)\ dx - \int_{2}^{4} (-0.3426\,x^2 + 3.7883\,x - 5.7986)\ dx$$
$$= 9.8322 - 4.7374 = 5.0948\ unit^2$$

$$Total\ of\ the\ lake\ area = Area(A) + Area(B) + Area(C)$$
$$= 1.4696523\ unit^2 + 4.69243334\ unit^2 + 5.0948\ unit^2$$
$$= 11.24688564\ unit^2$$
$$= 112568.8564\ m^2$$
$$= 0.112568564\ km^2$$
$$= 0.1126\ km^2$$

4. DISCUSSION

Discrete least square interpolation method offers numerous advantages, including accurate approximation of functions, the ability to handle missing or noisy data, and efficient computational capabilities. By capitalising on these benefits, a software can be developed based on the methodology provided in this study. The software can provide faster and optimal fitting of data points and enable precise estimations for the area of an object.

5. CONCLUSION

In conclusion, the discrete least squares interpolation method is a powerful tool for fitting models to data and is widely used in various fields, including statistics, econometrics, engineering, and data analysis. From this project, a set of data points was obtained to represent the boundaries of a region, fitting a curve or line to those points using the discrete least squares interpolation method. Hence, the least square function was integrated to calculate the area. By successfully developing a mathematical model for calculating the area of the lake in Seksyen 7, Shah Alam, this study will provide valuable insights into the lake's characteristics and contribute to urban planning, environmental management, and recreational activities in the area.

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