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Analysis of The Area Under A Curve (AUC) Using C-Programming: Trapezium and Simpson Rules Techniques

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Abstract

This study aimed to analyze the Area Under a Curve (AUC) using C-programming i.e. Trapezium and Simpson rules. There are various mathematical methods that can be applied to solve numerical integration for different data spaces. Among them are the Trapezium and Simpson rules which are widely used to solve numerical integration equations. The objective of this study was to study the calculation of the area under the curve more accurately and to identify the error differences between the Trapezium and Simpson rules in the calculation of the area under the curve. In addition, it also compares the fit between the Trapezium and Simpson rules. This study focuses on identifying methods that provide more accurate values in the area below the curve. C-programming study utility to verify the accuracy of area calculations under the curve between Trapezium and Simpson rules. The results showed a difference of 6.93% in the area under the curve for calculations using C-programming based on the Trapezium rule compared with the exact calculations. Meanwhile, a calculation difference of 6.23% was recorded for the Simpson rules. In general, the data show that the Simpson rules obtained a relatively low difference of 0.623 when compared to the Trapezium rule which yielded a value of 0.693 which means that the Simpson rule has a more accurate estimate value for AUC calculation using C- programming when compared to the Trapezium rules.
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Keywords: C-programming, Trapezium and Simpson rules, area under a curve.

INTRODUCTION

The Industrial Revolution 4.0 (IR4.0) has had a major impact on computing and software technology. It has significantly increased the demand for expert programmers. Therefore, there is a need to produce graduates in computer science and engineering who have good programming skills. Nevertheless, learning programming is very challenging among beginners. Many students claim it is difficult to understand the concept of programming and its implementation behaviour. Programming requires proficiency in a particular programming language. However, students, as novice programmers face the challenge of developing programs in syntactic, semantic and pragmatic aspects. This is reflected in the smoothness of their writing in the syntax of the language which results in unresolved syntax errors. They also have difficulty understanding program behaviour because of their inability to describe how the program works. As a result, it results in poor programming skills among novices. (Mohd Noor & Saad, 2021).

Furthermore, the purpose of this research is to analyze the estimated area under the graph to obtain a value that is close to the calculated value. There are many ways introduced to calculate the area under a curve nowadays. This research proposes the Trapezium and Simpson rules using C-programming to accurately calculate the area under a curve. The Trapezium and Simpson rules are among the popular methods used among students. However, dumping the area calculation method under a curve can raise the issue of confusion in obtaining the exact value for the calculation. Research using certain methods in obtaining accurate values can be identified (Ibrahim et. al, 2021).

The Trapezium and Simpson rules are both used to find the value of the definite integral approximation of a function. The Trapezium rule determines the area under the curve by approximating it with the area of the trapezoid i.e. The entire area between two given points and the x-axis, which are integral, can be approximated by adding several trapezoids. The Simpson rule utilize is the indentation with a sequence of quadratic parabolic segments rather than a straight line. This makes it more complex. Despite this, it is a method that produces values closer to the exact integral that is actually being determined. Areas bounded or attached by the function graphs, x-axis and vertical lines can be found through consolidation. They are also available with other closer methods. Therefore, the researcher studied these two methods, the Trapezium and Simpson rules in determining the nearest value in the area under the graph (Simpson, Simpson & Thalayasingam, 2020).

LITERATURE REVIEW

Information and Communication Technology (ICT) is very important in all fields, including mathematics. It can be used in online teaching and learning activities are Easy classes. Easy class is a usable e-learning platform for learning that provides many complete features, including talking to teachers with students and students via chat, creating assignments and quizzes for students with time constraints, providing learning materials, and more. In addition, Easy class provides privacy security features such as sending private messages and waiting for teacher approval to join special classes. In addition, technology is needed to help improve the mathematical capabilities of representation. Technology plays an important role in education in this era of globalization with the 4.0 revolution. There is research that uses Easyclass as an online classroom using feature classroom walls as additional lesson materials, assignments as student assignments and grade books as student values. So far Easyclass is used by researchers only for the process of learning discussion between teachers and students in the learning process. However, in this study Easyclass was used as a medium of learning material, media of quiz -conducted, and discussion between teachers and students. However, Easyclass does not provide features to illustrate a concept so it requires software that can illustrate mathematical concepts, one of which is GeoGebra (Valendry, 2021).

Area Under A Curve

The ability to calculate the area under a graph is one of the most important discoveries of integral calculus. Before calculus, the area was calculated by dividing the zones into very small bands and summing the respective areas. The accuracy of the result is improved only by making the band smaller and smaller, bringing the result towards some limiting value. In this section, we find out how integral calculus provides an event for calculating the area between a graph of a function and the x and y axes, (Simpson, Simpson & Thalayasingam, 2020). At a certain point, the differentiation gives the gradient of the curve. Integration has a wide range of applications covering quantity, heat, mass and fields of discovery. We estimated the region under the curve in the previous topic using the Trapezium and Simpson Rules, and the researcher is studying a more precise shape. Definite integral $\int_b^a (fx)dx$ gives a shaded area on the right. To find the area $f(x)$ between $x_0 = a$ and $x_1 = b$, the two x-values and the x-axis, as shaded in the example in Figure 1 are definite integral values between those values.

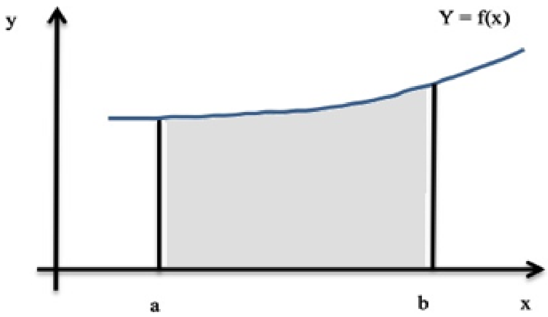

Figure 1: Shaped area under a curve

Trapezium Rule

The area under a curve with a function $f(x)$ between $a = x_0$ and $b = x_1$ approximated by a trapezoid. In this trapezoid $f(a)$ and $f(b)$ as the base and upper side and $b - a$ is the height of the trapezoid. Based on the Trapezium area formula it is obtained. Figure 2 illustrated the Trapezium rules figuration (Barnhart, 2016).

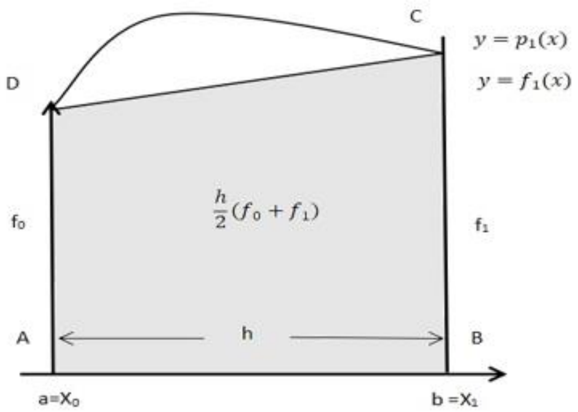

Figure 2: Trapezium rule

Using Newton's forward difference interpolation formula, we can write:

$p(x) = f_0 + r\Delta f_0$ with $r = \frac{x - x_o}{h}$

Hence,

$$\int_{a=x_o}^{b=x_1} f(x) = \int_{x_o}^{x_1} p_1(x)\,dx = \int_0^1 (f_0 + r\Delta f_0(hdx)$$

$$= h[rf_0 + \frac{r^2}{2}\Delta f_0] = h[f_0 + \frac{1}{2}\Delta f_0]$$

$$= h[f_0 + \frac{1}{2}(f_1 - f_0) = h[\frac{1}{2}f_0 + \frac{1}{2}f_1]$$

$$= \frac{h}{2}(f_0 + f_1) \qquad = \frac{h}{2}[f(a) + f(b)$$

(= area of Trapezium ABCD)

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Next, if the integral interval [a, b] is large then the accuracy of the integral value $\int_a^b f(x)\,dx$ can be improved by dividing the integral interval [a, b] by (n an even number) the actual sub-interval of width h by (n + 1) points. Figure 3 illustrated the Trapezium rules composition.

$$\{a = x_0, x_1, \dots . x_{n-1,} x_n = b\}$$

Thus,

$$x_i - x_0 + ih \; and \; h - \frac{b-a}{n}$$

The total area is given

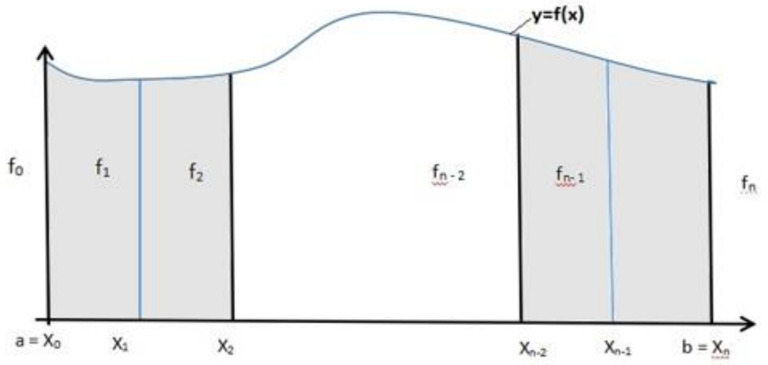

Figure 3: Composition of Trapezium rules

$$\int_a^b f(x)\,dx = \int_{x_0}^{x_2} f(x)\,dx + \int_{x_2}^{x_4} f(x)\,dx + \dots\dots + \int_{x_{n-1}}^{x_{n-2}} f(x)\,dx + \int_{x_{n-2}}^{x_{b=b}} f(x)\,dx$$

Hence, the total area given by:

$$\int_a^b f(x)\,dx \approx \frac{h}{2}(f_0 + f_1) + \frac{h}{2}(f_1 + f_2) + \dots . \frac{h}{2}(f_{n-2} + f_{n-1}) + \frac{h}{2}(f_{n-1} + f_n)$$

$$\approx \frac{h}{2}[(f_0 + f_n) + 2(f_1 + f_2 + \dots . + f_{n-1})]$$

Simpson Rule

The Simpson rule uses a quadratic or parabolic $p(x)$ interpolation approximation to what is to be integrated $f(x)$ (Gangele, 2014). Figure 4 illustrated the Simpson rules figuration.

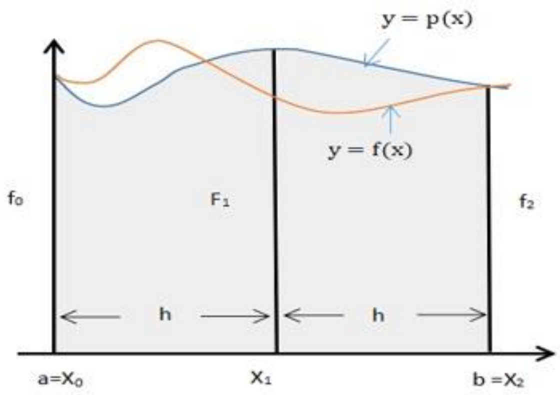

Figure 4: Simpson rule figuration

Using Newton's forward difference interpolation formula, we can write:

$P_2(x) = f_0 + r\Delta f_0 + \frac{r(r-1)}{2!}\Delta^2 f_0$ with $r = \frac{x-x_0}{h}$

Hence,

$$\int_{a=x_0}^{b=x_2} f(x)dx \approx \int_{x_0}^{x_2} p_2(x)\, dx$$

$$\approx \int_0^2 (f_0 + r\Delta f_0 + \frac{r(r-1)}{2!}\Delta^2 f_0)\ (hdx)$$

$$\approx h[xf_0 + \frac{r^2}{2}\Delta f_0 + \frac{1}{2}(\frac{r^3}{3} - \frac{r^2}{2})\Delta^2 f_0]\,_0^2$$

$$\approx h[2f_0 + 2\Delta f_0 + \frac{1}{2}(\frac{2}{3})\Delta^2 f_0]$$

$$\approx h[2f_0 + 2(f_1 - f_0) + \frac{2}{3}(f_2 - 2f_1 + f_0]$$

$$\approx \frac{h}{3}(f_0 + 4f_1 + f_2]$$

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Hence,

$$\int_a^b f(x)\,dx \approx \frac{h}{3}(f(a) + 4f(a+h) + f(b)],\ h = \frac{b-a}{2}$$

Next, if the integral interval [a, b] is large then the accuracy of the integral value $\int_a^b f(x)\,dx$ can be improved by dividing the integral interval [a, b] by (n an even number) the actual interval of width h by (n + 1) points

$$\{a = x_0, x_1, \ldots. x_{n-1,} x_n = b\}$$

Thus,

$$x_i - x_0 + ih \; and \; h - \frac{b-a}{n}$$

Total of area is given

$$\int_a^b f(x)\,dx = \int_{x_0}^{x_2} f(x)\,dx + \int_{x_2}^{x_4} f(x)\,dx + \ldots\ldots + \int_{x_{n-1}}^{x_{n-2}} f(x)\,dx + \int_{x_{n-2}}^{x_{b=b}} f(x)\,dx$$

Hence, the total area is given by:

$$\int_a^b f(x)\,dx \approx \frac{h}{3}(f_0 + 4f_1 + f_2) + \frac{h}{3}(f_2 + 4f_3 + f_4) + \ldots. \frac{h}{3}(f_{n-2} + 4f_{n-1} + f_n) \ldots.$$

$$\int_{X0}^{Xn} f(x) = \frac{h}{3}[(f_0 + f_n) + 4(f_1 + f_3 + \ldots. + f_{n-1}) + 2(y_2 + f_4 + \ldots + f_{n-2})]$$

METHODOLOGY

The C language is very simple because the programs coded in it are faster and more efficient. This makes learning C easier than other programming languages. You can understand the concept behind C easily as there are not many keywords or symbols involved. Also, you don't have to be an expert in computer science to start C programming. Also, the C language uses ASCII characters, it works well across different platforms including Windows, Linux, Mac OS X, Android, iOS, etc. So, you can run your C program anywhere regardless of where you live. Numerical method techniques are used to solve these equations; this involves some computation and efforts have been made to reduce errors in the program. The trapezoidal rule can be used as a method of calculating the area under a curve because the area under a curve is given by the integral. Thus, the trapezoidal rule provides a method for calculating integrals (Liu, et al, 2022).

A computer programmer is a computer scientist who is skilled at using the constructs of a programming language to develop executable and acceptable computer programs. Software developers are programmers. Programmers often work with systems analysts for large projects. A programming language is an artificial notation language created or developed for use in the preparation of coded instructions on a computer for later execution by a computer. They usually consist of a set of usage rules that determine the meaning of expressions written in a language. Each programming language is useful with its own translator i.e. an interpreter or compiler according to its suitability. Programming is the art of developing a computer program with the help of a programming language selected by a computer programmer. These are special skills whose quality is tested by the quality of the program or software produced. In programming, the level of programming should be followed precisely, i.e. from problem definition to maintenance and survey (Valendry, 2021).

This study uses the c programming method to solve the problem that if n value or interval is too small, then the manual calculation is too difficult to do Therefore, an algorithm using c programming has been developed to help solve problems on relatively complex and difficult integration equation. A number of integrals need to be solved in mathematics, physics and applied engineering (Upmanyu et al, 2016). Manual analytical solutions for consolidation are of course quite complicated and time-consuming. Thus, Figure 5 (a) and (b) shows the source code in C programming for trapezoidal and Simpson rules as one of the ultimate computer-based integration solutions. The main reason for choosing C over other programming languages is its simplicity.

```
int main(){
int n,i;
double a,b,h,x,sum=0,integral;
/*Ask the user for necessary input */
printf("\nEnter the no. of sub-intervals(EVEN): ");#include<stdio.h>
#include<math.h>

/* Define the function to be integrated here: */
double f(double x){
return x*x-4;
}
/*Program begins*/
int main(){
int n,i;
double a,b,h,x,sum=0,integral;
/*Ask the user for necessary input */
printf("\nEnter the no. of sub-intervals: ");
scanf("%d",&n);
printf("\nEnter the initial limit: ");
scanf("%lf",&a);
printf("\nEnter the final limit: ");
scanf("%lf",&b);
/*Begin Trapezoidal Method: */
h=fabs(b-a)/n;
for(i=1;i<n;i++){
x=a+i*h;
sum=sum+f(x);
}
integral=(h/2)*(f(a)+f(b)+2*sum);
/*Print the answer */
printf("\nThe integral is: %lf\n",integral);
}
```

Figure 5(a): C- programming for Trapezium rules

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```
#include<stdio.h>
#include<math.h>

/* Define the function to be integrated here: */
double f(double x){
return x*x-4;
}
/*Program begins*/
int main(){
int n,i;
double a,b,h,x,sum=0,integral;
/*Ask the user for necessary input */
printf("\nEnter the no. of sub-intervals(EVEN): ");
scanf("%d",&n);
printf("\nEnter the initial limit: ");
scanf("%lf",&a);
printf("\nEnter the final limit: ");
scanf("%lf",&b);
/*Begin Simpson's Procedure: */
h=fabs(b-a)/n;
for(i=1;i<n;i++){
x=a+i*h;
if(i%2==0){
sum=sum+2*f(x);
}
else{
sum=sum+4*f(x);
}
}
integral=(h/3)*(f(a)+f(b)+sum);
/*Print the answer */
printf("\nThe integral is: %lf\n",integral);
}
```

Figure 5(b): C- programming for Simpson rules

RESULT ANALYSIS

Table 1 shows the calculation using the Trapezium rules assisted by C-programming to facilitate the calculation. The purpose of using C-programming is to see the difference in the area under a curve if using different values of n (number of trapezoids). Analysis using C-programming to determine the estimated value of the area under the graph has been carried out. Some examples of questions have been successfully calculated using C-programming. Each question is calculated and compared with the calculated value using a Trapezium rule and a scientific calculator. Calculations using a Scientific calculator are considered accurate calculations compared to using Trapezium and Simpson rules. The result of the analysis obtained is that the maximum error value is 6.93% for question number 5 while the minimum error obtained is 0.27% which is question number 2.

Table 1: Calculation using Trapezium rule

Question	Area under a Curve			
	Trapezium ($unit^2$)	**Calculator ($unit^2$)**	**Error or difference**	**% Error or difference**
$\int_0^4 8x - 2x^2, n = 8$	21	21.333	0.333	1.56
$\int_0^3 3x - x^2, n = 20$	4.488	4.5	0.012	0.27
$\int_2^6 x^2 + 2, n = 18$	77.36	77.333	-0.0027	-3.49
$\int_0^3 15 - x^2, n = 6$	35.87	36	0.13	0.36
$\int_0^4 \sqrt{2}\sqrt{x}, n = 8$	7.445	8	0.555	6.93

Table 2 shows the calculation using C-programming for Simpson rule or method and calculation using calculator. The results show that the Simpson rule obtained the highest value of error is 6.23% for question number 5. While the other questions are 0% error compared to the accurate calculation that is using a scientific calculator.

Table 2: Calculation using Simpson rule

Questions	Area Under a Curve			
	Simpson ($unit^2$)	**Calculator ($unit^2$)**	**Error or difference**	**% Error or difference**
$\int_0^4 8x - 2x^2, n = 8$	21.333	21.333	0	0
$\int_0^3 3x - x^2, n = 20$	4.5	4.5	0	0
$\int_2^6 x^2 + 2, n = 18$	77.333	77.333	0	0
$\int_0^3 15 - x^2, n = 6$	36	36	0	0
$\int_0^4 \sqrt{2}\sqrt{x}, n = 8$	7.501	8	0.499	6.23

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CONCLUSION

Through the analysis conducted on the above questions, the researcher has used the highest value of n which is 20, while the lowest value of n is 6. By using the C-programming that has been developed it can facilitate and speed up the calculation of the area estimate under a curve compared to the conventional methods used before this by students. The analysis is conducted using C-programming on some integration questions that are quite difficult to solve manually. The proposed, method simplifies and saves time for calculations compared to using C-programming. The results show that the Simpson rule calculation using C-programming is a more accurate method for estimating the area under a curve compared to the Trapezium rules.

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