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Analysis of Travel Time Approximation on Trips Using Maclaurin Series

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Abstract
Mathematical approximation plays an important role in the analysis of travel time which is influenced by factors such as speed, distance, and acceleration. This study uses the Maclaurin series to approximate the value of travel time based on the distance traveled (x) and the number of terms in the series (n). The calculation was done manually and implemented using MATLAB for the case of distance x = 2 with the first five terms n = 5. The results of the manual calculation showed an estimated travel time of 0.9094 seconds, while the calculation using MATLAB resulted in 0.9093 seconds. The small difference between the two methods shows the accuracy of the Maclaurin series in travel time approximation. By increasing the number of terms in the sequence, the calculation results will be closer to a more precise value. This study emphasizes the benefits of the Maclaurin sequence method in simplifying mathematical analysis and improving calculation efficiency in physical and computational applications.
Keywords: Maclaurin, MATLAB, Approximation

INTRODUCTION

Mathematical approximation plays an important role in many fields, including travel planning and travel time analysis. In the context of travel, travel time is often affected by many factors that can be calculated mathematically, such as speed, distance, and acceleration. However, in some cases, the formulas used to calculate travel time can be very complex and difficult to apply directly. In straight line motion, GLB is the motion of an object whose trajectory is straight and whose speed is constant (fixed). An example of GLB motion is a car moving on a straight road and at a fixed speed. The equation used in GLB is as follows: v = x/t Description: x is the distance or displacement (m) v is the speed or velocity (m/s) t is the time taken (s). The Maclaurin series is one of the methods in mathematical analysis used to approach the value of a function using an infinite series. This method can help simplify complex calculations by providing a reasonably good approximation to the value of the function in relatively small intervals. In the case of travel, Maclaurin series can be used to approximate functions that describe the relationship between variables such as speed, acceleration, and travel time. MATLAB (Matrix Laboratory) is a numerical computing environment and fourth generation computer programming language that is widely used to solve various problems involving computational processes in various fields. As an advanced programming language, MATLAB uses Matrix as a rationale in analysis and computation. In this research, the author conducted a manual analysis and implementation into MATLAB to calculate travel time using the Maclaurin series. This analysis not only provides theoretical insights but also shows the practical application of the Maclaurin sequence in modeling complex physical phenomena.

RESEARCH METHODS

In writing this article, the author uses analytical methods and also computational methods to analyze the travel time of a trip. The analytical method itself is an approach that uses

mathematical calculations in the form of formulas or theories to solve problems. While the computational method is an approach that uses computational tools to solve problems. However, in more complex cases, such as when using Maclaurin series to calculate travel time based on varying speeds, analytical methods often become very complicated and require in-depth calculations. This is where computational methods become very useful. Computational methods involve using computational tools or devices, such as MATLAB, to solve more complex problems. In this research, MATLAB is used to implement the Maclaurin series, which allows for faster calculations.

RESEARCH RESULTS AND DISCUSSION

The calculation results on travel time using the Maclaurin series for the distance value x = 2km, then using the first 5 terms of the Maclaurin series (value n = 5). In general, we can relate the travel time t(x). In the Maclaurin series formula, the function f(x) can be written in the form of a Maclaurin series:

$$f(x) = f(0) + f'(0)x + \frac{f''(0)}{2!}x^2 + \frac{f'''(0)}{3!}x^3 + \cdots$$

In the case of this analysis, we use a formula that can calculate travel time based on changes in velocity where, for example, the function involves sin (x) or the derivative of arcsin (x), which produces a Maclaurin series with a pattern:

$$t(x) \approx x - \frac{x^3}{3!} - \frac{x^5}{5!} - \frac{x^7}{7!} + \frac{x^9}{9!} \ldots$$

The calculation is done manually first using the Maclaurin series formula and then analyzed in MATLAB.

First term

$$t_1 = 2$$

Second term

$$t_2 = -\frac{2^3}{3!} = -\frac{8}{6} = -1.3333$$

Third term

$$t_3 = \frac{2^5}{5!} = \frac{32}{120} = 0.2667$$

Fourth term

$$t_4 = -\frac{2^7}{7!} = -\frac{128}{5040} = -0.0254$$

Total after Fourth term

$$t(x) = 0.9334 - 0.0254 = 0.9080$$

Fifth term

$$t_5 = \frac{2^9}{9!} = \frac{512}{362880} = 0.0014$$

Total after Fifth term

$$t(x) = 0.9080 + 0.0014 = 0.9094$$

In the manual calculation using the Maclaurin sequence formula, we found that by using the first 5 terms of the Maclaurin sequence, the estimated travel time for distance x=2x=2 is 0.9094 seconds. For the implementation of the code in MATLAB to estimate travel time based on the Maclaurin sequence, we can see in Picture 1 and Picture 2.

Picture 1.

Editor - C:\Users\ASUS\Documents\Matlab File\fungsi.m

fungsi.m | fungsiwaktutempuh.m

```
% fungsi.m
x = 2;  % jarak tempat yang ditempuh
n = 5;  % 5 suku pertama

% waktu tempuh menggunakan deret Maclaurin
waktu = fungsiwaktutempuh(x, n);

% menampilkan hasil
fprintf('perkiraan waktu tempuh untuk jarak tempat %.2f adalah %.4f second\n', x, waktu);
```

Picture 2.

Editor - C:\Users\ASUS\Documents\Matlab File\fungsiwaktutempuh.m

fungsi.m | fungsiwaktutempuh.m

```
% fungsiwaktutempuh.m
function t = fungsiwaktutempuh(x, n)
    t = 0; % konfigurasi awal waktu tempuh
    for k = 0:n-1

        % rumus untuk suku ke-k
        t = t + ((-1)^k * x^(2*k+1)) / factorial(2*k+1);
    end
end
```

In the MATLAB implementation, the calculation of travel time approximation using the Maclaurin series is done by inputting two main parameters, namely the distance traveled (x) and the number of terms in the series (n). In this case, the distance (x) was set at 2, and the number of terms used was the first five terms (n=5). It was found that the results of manual and MATLAB calculations were almost the same, where in manual calculations the result was 0.9094 seconds while in MATLAB 0.9093 seconds. MATLAB results can be seen in Figure 3, where the command window shows the results.

Picture 3.

Command Window

```
>> fungsi
perkiraan waktu tempuh untuk jarak tempat 2.00 adalah 0.9093 second
>> fungsiwaktutempuh(x, n)

ans =

    0.9093
```

CONCLUSION

The conclusion of this study shows that mathematical approximation has a significant role in the analysis of travel time. Using the Maclaurin series, the author successfully calculated the travel time for a distance of 2 km, which resulted in an estimated time of 0.9094 seconds manually and 0.9093 seconds through implementation in MATLAB. These results show that the Maclaurin sequence method can provide an accurate approach in calculating travel time based on the distance traveled (x) and the number of terms in the sequence (n). By adding more terms to the Maclaurin sequence, the difference between manual results and MATLAB results will decrease, and the calculated value will be closer to a more accurate value.

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