

Research Article

The Velocity of an Object by Using Discrete Least Square Method for Teaching and Learning Processes

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Abstract: The present study experimentally calculated velocity of an object by using Discrete Least Square Method for learning and teaching processes. Problems can occur if this method is not implemented. One of those problems is calculations that are done manually are open to human error. The velocity calculation could be very inaccurate even with the tiniest measurement or calculation error. Next, manual calculations need a lot of time and operating cost. This becomes increasingly challenging when dealing with substantial amounts of data or complicated measurements. Furthermore, manual calculations are limited by the level of accuracy of the measuring tools used and the capability of humans to conduct exact measurements. Solutions must be applied to minimize the problem occurring. To obtain accurate calculations of velocities, we can use the Discrete Least Square method. It can determine the function of $V(t)$, then derive the function's curve by minimizing the costs and energy. Our community and industry will get the benefit from this solution which is that relate to time and operating cost. Calculating velocity with software is far more efficient than performing so manually since software can handle enormous amounts of data quickly.

Keywords: Discrete Least Square Method; velocity calculation; teaching and learning



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1. INTRODUCTION

In this research study, we intend to implement mathematical numerical approaches for calculating velocity. As we know distance is an object's motion that takes place without consideration for direction. The starting point and ending point may be used to compute it. When an object (like a car) is self-propelled, it moves. For motion to effectively carry out a mechanical task, energy must be transferred from the vehicle's engine or the agent's arm to the item with efficiency. (Duric, Z., Rivlin, E., & Rosenfeld, A., 1998)

Furthermore, the perceived distance of an object within a stationary scene is influenced by its contact point with the ground in the image or by the intricate interplay of contact relationships among intermediate surfaces (George J. Anderson, 2005). In this study, our primary focus is on the calculation

of velocity using the data we have collected, specifically time and distance. However, the precise determination of the distance function is a time-consuming and labor-intensive process. To mitigate these challenges, the Discrete Least Square Method is proposed as a valuable tool for efficiently obtaining velocity, utilizing the information available to the user.

It is noteworthy that speed and velocity, while distinct concepts, are at times used interchangeably (Ali Yildiz, 2016). This present study aims to further advance the development of the numerical approach, specifically the discrete method prototype, for the calculation of velocity.

This research endeavor aims to employ mathematical numerical methods for the computation of velocity. It is important to note that distance represents the motion of an object without considering its direction, and it can be determined using the initial and final positions. When an object, such as a self-propelled vehicle like a car, is in motion, energy transfer from the engine or the agent's force is essential to perform mechanical work efficiently (Duric, Z., Rivlin, E., & Rosenfeld, A., 1998).

2. METHOD & MATERIAL

The Discrete Least Square method is designed to help calculate velocity from the data that we obtain. The least squares method, sometimes referred to as the least squares approximation, and is a differential equation technique that estimates a quantity's real value by considering measurement or observational errors. A formula called the least squares requirements is used to determine how precise a straight line is in the data representation that led to it. That is, the formula decides the best-fit rows. (Salisu Ibrahim, 2022) The method can minimize the cost of doing the calculation manually and maximize production which is the result can be obtained easily. Through the process, the user must fill up the required inputs to obtain the desired output. Using discrete Least Square method can make the learning process more effective and realistic, integrating computer technology into mathematics instruction will assist students in developing connections in the subject (Hartsell, Herron, Fang, & Rathod, 2009; Horton, Storm, & Leonard, 2004; Lavicza, 2010; Saha, Job, & Tarmizi, 2010).

Figure 1 shows the flowchart of the prototype which is Discrete Least Square Method (DLSM) and there also has five interfaces.

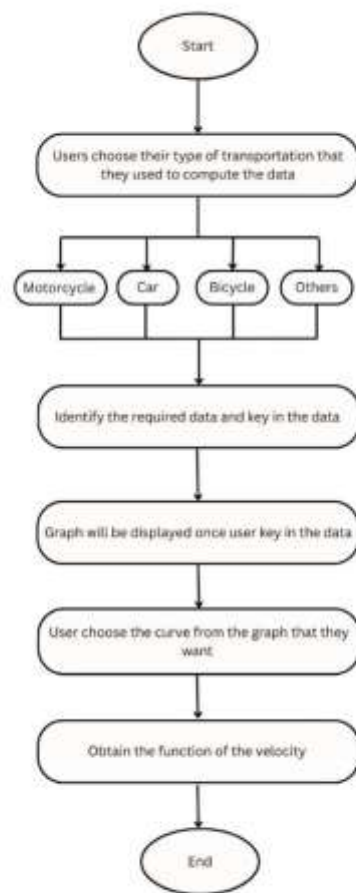


Figure 1. Flowchart of DLSM (Discrete Least Square Method) Calculations



Figure 2. First interface: Press the 'Start' button



Figure 3. Second interface: Users choose the type of transportation that they used

The image shows a user interface titled "Fill your data" in a dark blue box at the top left. The background is a light gray with a faint circuit pattern. In the top right corner, the text "DLSM" is visible. Below the title, there are two rows of input fields:

- Time (hour)**: A row of 10 empty rectangular boxes.
- Velocity (km/h)**: A row of 10 empty rectangular boxes.

 At the bottom right, there is a green button with the text "NEXT" and a right-pointing arrow.

Figure 4. Third interface: Users key in the required data and press 'next' to obtain graph of 'Time vs Velocity.'

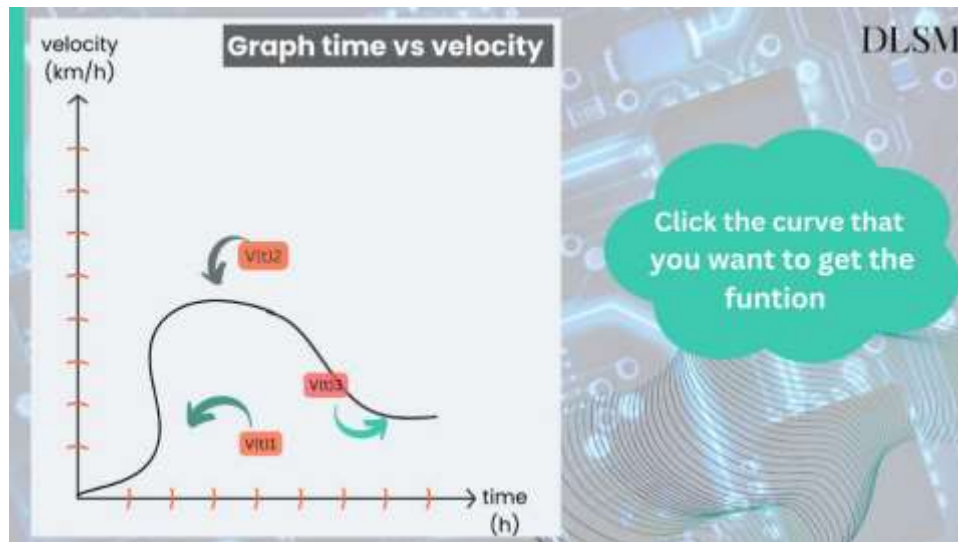


Figure 5. Fourth interface: Click and choose the curve to get the function that we want.

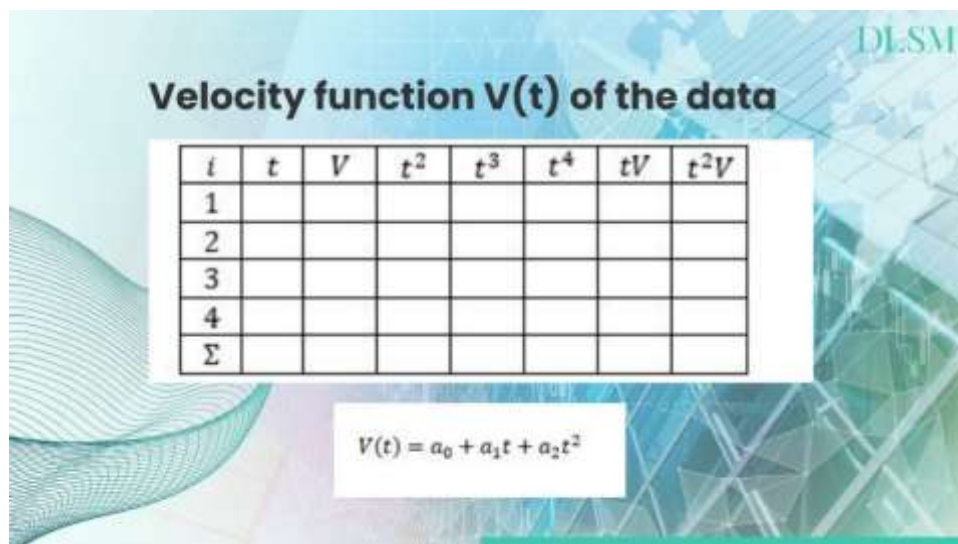


Figure 6. Fifth interface: The function will be displayed on the screen.

3. FINDINGS

This is the data after we collected it manually without using any software. Table of time(h) and velocity(km/h) shown below:

Table 1. Table of time(h) and velocity(km/h)

Time (h)	0	1/20	1/60	1/40	1/30	1/24	1/20	7/120	1/15	3/40	1/12	11/120	1/10
Velocity (km/h)	0	11.9	14.3	18.9	20.6	21.4	22.4	22.3	23.3	24.2	24.0	23.9	24.0

From the data we collect, we can plot the graph and obtain time versus velocity.

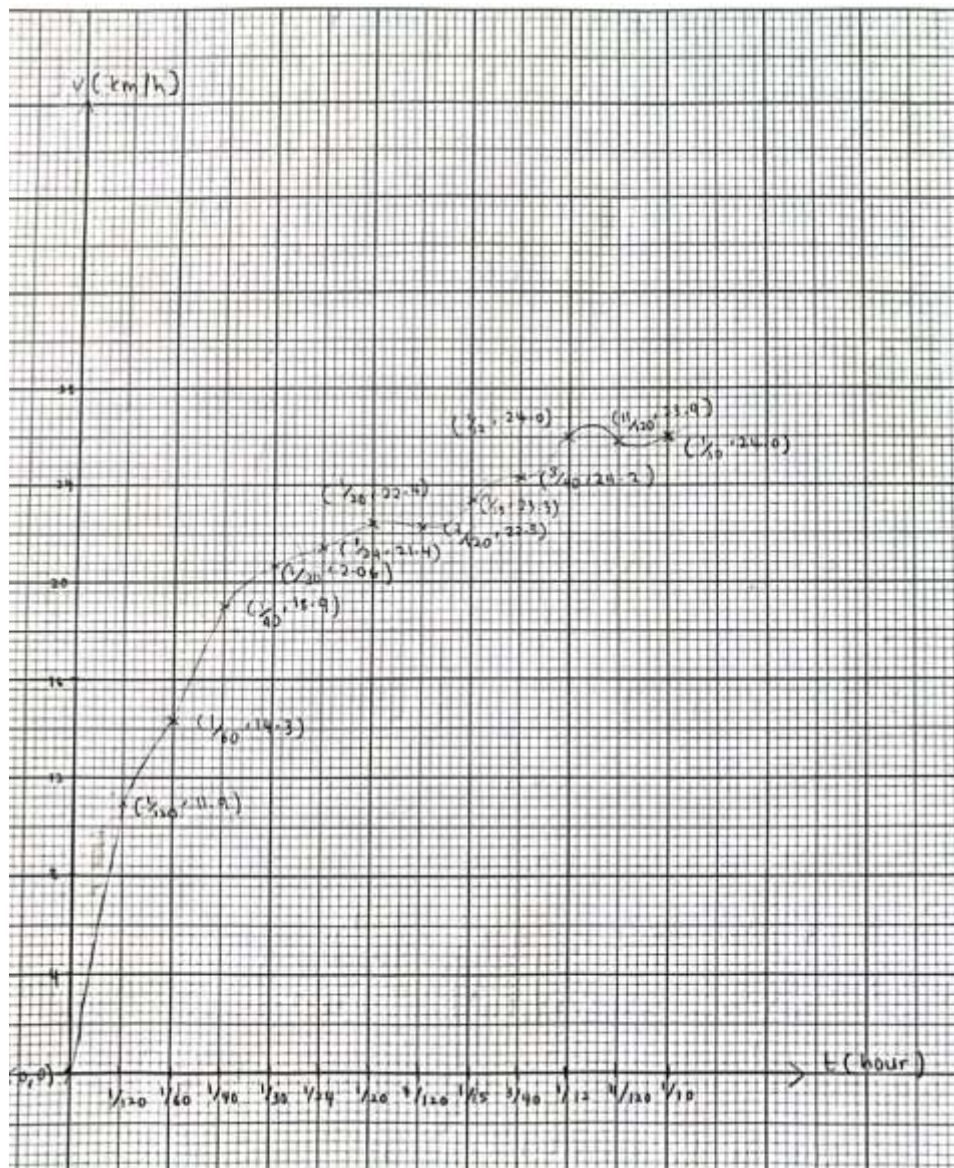


Figure 7. Picture shows the graph time versus velocity after the data plotted.

From the graph, we can see that there are a few curves connected that can be divided into three parts. Then, we can start calculating it using discrete least square method to get the function of $V(t)$. Since we divided into three parts, so there are three functions of $V(t)$.

For V(t)1,

n	Σt	Σt^2	Σt^3	Σt^4	Σv	Σtv	$\Sigma t^2 v$
1	0	0	0	0	0	0	0
2	$\frac{1}{20}$	$\frac{1}{400}$	$\frac{1}{8000}$	$\frac{1}{160000}$	11.9	$\frac{119}{1200}$	$\frac{119}{4000}$
3	$\frac{1}{60}$	$\frac{1}{3600}$	$\frac{1}{216000}$	$\frac{1}{12960000}$	14.3	$\frac{143}{600}$	$\frac{143}{36000}$
4	$\frac{1}{40}$	$\frac{1}{1600}$	$\frac{1}{64000}$	$\frac{1}{2560000}$	18.9	$\frac{189}{400}$	$\frac{189}{16000}$
5	$\frac{1}{30}$	$\frac{1}{900}$	$\frac{1}{27000}$	$\frac{1}{810000}$	20.6	$\frac{103}{150}$	$\frac{103}{4500}$

$$\begin{bmatrix} n & \Sigma t & \Sigma t^2 \\ \Sigma t & \Sigma t^2 & \Sigma t^3 \\ \Sigma t^2 & \Sigma t^3 & \Sigma t^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \Sigma v \\ \Sigma tv \\ \Sigma t^2 v \end{bmatrix}$$

$$\begin{bmatrix} 5 & \frac{1}{12} & \frac{1}{480} \\ \frac{1}{12} & \frac{1}{480} & \frac{1}{17280} \\ \frac{1}{480} & \frac{1}{17280} & 0.000001707 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} 65.7 \\ 1.4967 \\ 0.0395 \end{bmatrix}$$

$$a_0 = 0.8901 \quad a_1 = 1204.6282 \quad a_2 = -18785.4066$$

$$v(t)_1 = 0.8901 + 1204.6282t - 18785.4066t^2$$

For V(t)2,

n	Σt	Σt^2	Σt^3	Σt^4	Σv	Σtv	$\Sigma t^2 v$
1	$\frac{1}{24}$	$\frac{1}{576}$	$\frac{1}{13824}$	$\frac{1}{331776}$	21.4	$\frac{107}{120}$	$\frac{107}{2880}$
2	$\frac{1}{20}$	$\frac{1}{400}$	$\frac{1}{8000}$	$\frac{1}{160000}$	22.4	$\frac{28}{25}$	$\frac{7}{125}$
3	$\frac{7}{120}$	$\frac{49}{14400}$	$\frac{343}{1728000}$	0.00001158	22.3	$\frac{1561}{1200}$	0.07588
4	$\frac{1}{15}$	$\frac{1}{225}$	$\frac{1}{3375}$	$\frac{1}{50625}$	23.3	$\frac{233}{150}$	$\frac{233}{2250}$
Σ	$\frac{13}{60}$	$\frac{29}{2400}$	0.0006921	0.000040596	4.8658 89.4 89.4	4.8658	0.2726

$$\begin{bmatrix} n & \Sigma t & \Sigma t^2 \\ \Sigma t & \Sigma t^2 & \Sigma t^3 \\ \Sigma t^2 & \Sigma t^3 & \Sigma t^4 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \Sigma v \\ \Sigma tv \\ \Sigma t^2 v \end{bmatrix}$$

$$\begin{bmatrix} 4 & \frac{13}{60} & \frac{29}{2400} \\ \frac{13}{60} & \frac{29}{2400} & 0.0006921 \\ \frac{29}{2400} & 0.0006921 & 0.000040596 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} 89.4 \\ 4.8658 \\ 0.2726 \end{bmatrix}$$

$$a_0 = 20.4137 \quad a_1 = 2.4250 \quad a_2 = 597.5073$$

$$v(t)_2 = 20.4137 + 2.4250 t + 597.5073 t^2$$

For V(t)3,

n	Σt	Σt^2	Σt^3	Σt^4	Σv	Σtv	$\Sigma t^2 v$
1	$\frac{3}{40}$	$\frac{9}{1600}$	$\frac{27}{64000}$	$\frac{81}{2560000}$	24.2	$\frac{363}{200}$	$\frac{1089}{8000}$
2	$\frac{1}{12}$	$\frac{1}{144}$	$\frac{1}{1728}$	$\frac{1}{20736}$	24.0	2	$\frac{1}{6}$
3	$\frac{11}{120}$	$\frac{121}{400}$	0.0007703	0.0007061	23.9	$\frac{2629}{1200}$	0.2008
4	$\frac{1}{10}$	$\frac{1}{100}$	$\frac{1}{1000}$	$\frac{1}{10000}$	24.0	$\frac{12}{5}$	$\frac{6}{25}$
Σ	$\frac{7}{20}$	$\frac{233}{7200}$	$\frac{133}{48000}$	0.0002504	$\frac{961}{10}$	$\frac{10087}{1200}$	0.7436

$$\begin{bmatrix} 4 & \frac{7}{20} & \frac{223}{7200} \\ \frac{7}{20} & \frac{223}{7200} & \frac{133}{48000} \\ \frac{223}{7200} & \frac{133}{48000} & 0.0002504 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \end{bmatrix} = \begin{bmatrix} \frac{968}{10} \\ \frac{10087}{1200} \\ 0.7436 \end{bmatrix}$$

$$a_0 = 24.3656 \quad a_1 = 0.7172 \quad a_2 = -52.0981$$

$$v(t)_3 = 24.3656 + 0.7172t - 52.0981t^2$$

4. DISCUSSION

The discussion of our project was undertaken collaboratively by our research team. Initially, we procured dataset comprising temporal measurements in hours and corresponding velocities in kilometers per hour. To gather this dataset, we employed a motorcycle and periodically observed the speedometer at 30-second intervals while navigating around the Universiti Teknologi MARA (UiTM)

campus. Approximately 12 to 17 data points were collected during this process, and we ultimately utilized 13 of these data points for graph construction.

After acquiring the requisite dataset, we proceeded to generate a graphical representation with the axis labels "time versus velocity," based on the accumulated data. The resulting graph exhibited a distinctive parabolic shape, leading us to conclude that the velocity $V(t)$ functions could be represented as quadratic equations. Subsequently, we partitioned the graph into three distinct segments, and applied the Discrete Least Square Method to derive the velocity functions $V(t)$ for each of these segments. Prior to obtaining the functions, we ensured that all data underwent the necessary computations as dictated by the relevant formulas.

The rationale behind dividing the curve into three segments was to facilitate the accuracy of calculations, as dividing the curve reduced the potential for human errors that might arise when dealing with the entire curve in a single computation. Ultimately, we successfully derived the desired velocity functions $V(t)$.

Furthermore, our findings section encompasses the presentation of prototypes. These prototypes encompass five distinct interfaces that are designed to guide users through the process. Firstly, users are prompted to initiate the process by clicking the 'start' button, which advances them to the subsequent interface. Secondly, users are required to select their mode of transportation. Thirdly, users input their collected data in order to generate the 'time versus velocity' graph.

Subsequently, the prototype displays the graph, which is divided into multiple segments. Users are tasked with selecting and clicking on the specific segment of the graph from which they wish to obtain the velocity function $V(t)$. Ultimately, the selected $V(t)$ function is presented to the user as per their preference.

5. CONCLUSION

In conclusion, the use of the Discrete Least Square Method (DLSM) offers a streamlined means to acquire the velocity function, eliminating the need for manual derivation. Additionally, it has been demonstrated that the least-squares approach constitutes a valuable tool for addressing a wide array of engineering-related optimization problems (Brendan Keith, Socratis Petrides, Federico Fuentes, & Leszek Demkowicz, 2017). Manual determination of the velocity function can be a time-consuming and costly endeavour. Notably, the integration of fundamental numerical computation tools in environmental engineering practice and education has been proven to be advantageous for modelling and simulation (Asher Brenner et al., 2004).

Moreover, the implementation of copyright safeguards not only fosters the long-term sustainability and advancement of the software industry but also incentivizes software engineers to invest in research and development, leading to the creation of effective, high-quality, and continually evolving mathematical software. This benefits both developers and end users, as well as the domains of scientific research and education. Copyright protection plays a pivotal role in stimulating innovation and nurturing a robust ecosystem for mathematical software.

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