

Modeling and Simulation of Vehicle Velocity-Density on Buah Batu Road Using Decision Tree Regression

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Abstrak

Penelitian ini bertujuan untuk mengeksplorasi dan mensimulasikan model aliran lalu lintas di Jalan Buah Batu menggunakan fungsi kecepatan-kepadatan yang dihasilkan oleh metode Decision Tree Regression. Model ini menggunakan pendekatan makroskopik, khususnya model Lightill, Whitham, dan Richards (LWR), yang mempertimbangkan interaksi antar kendaraan. Data observasi dikumpulkan langsung dari Jalan Buah Batu dan diproses untuk menghasilkan fungsi kecepatan-kepadatan, yang menunjukkan bahwa kecepatan kendaraan menurun seiring dengan meningkatnya kepadatan, mengikuti pola yang tidak linear tetapi berbentuk langkah-langkah. Fungsi kecepatan yang dihasilkan oleh Decision Tree Regression menunjukkan bahwa pada kepadatan rendah ($\rho < 0,102$), kecepatan rata-rata diprediksi berada di sekitar 3,681 hingga 4,551, sementara pada kepadatan tinggi ($\rho > 0,273$), kecepatan turun menjadi sekitar 1,411 atau lebih rendah. Simulasi dilakukan pada segmen jalan sepanjang 40 meter dengan total waktu simulasi 5 menit dan resolusi grid sebanyak 300 titik. Pada awal simulasi, kepadatan puncak 0,70 tercatat pada segmen 15-25 meter, yang kemudian bergeser dan menurun menjadi 0,50 pada segmen 30-50 meter di akhir simulasi. Hasilnya menunjukkan bahwa pergerakan kendaraan mengurangi kepadatan dan memperbaiki aliran lalu lintas. Dengan demikian, metode Decision Tree Regression terbukti efektif dalam memodelkan dan mensimulasikan hubungan kecepatan-kepadatan untuk memahami dinamika lalu lintas di Jalan Buah Batu.

Kata kunci: *Simulasi, Decision Tree Regression, Kecepatan-Kepadatan*

Abstract

This study aims to explore and simulate the traffic flow model on Buah Batu Road using the velocity-density function generated by the Decision Tree Regression method. The model utilizes a macroscopic approach, specifically the Lightill, Whitham, and Richards (LWR) model, which considers vehicle interactions. Observational data were collected directly from Buah Batu Road and processed to produce a velocity-density function, which shows that vehicle speed decreases as density increases, following a non-linear but step-like pattern. The velocity function generated by the Decision Tree Regression indicates that for low density ($\rho < 0.102$), the average speed is predicted to be around 3.681 to 4.551, while at high density ($\rho > 0.273$), the speed drops to around 1.411 or lower. The simulation was conducted on a 40-meter road segment with a total simulation time of 5 minutes and a grid resolution of 300 points. At the beginning of the simulation, a peak density of 0.70 was recorded in the 15-25 meter segment, which then shifted and decreased to 0.50 in the 30-50 meter segment by the end. The results indicate that vehicle movement reduces density and improves traffic flow. Thus, the Decision Tree Regression method has proven effective in modelling and simulating the velocity-density relationship to understand traffic dynamics on Buah Batu Road.

Keywords: *Simulation, Decision Tree Regression, Velocity-Density*

1. Introduction

Traffic congestion tends to occur in areas with high activity intensity and extensive land use (Putri Kanjeng Octavia & Herison Ahmad, 2019). Traffic congestion is a common issues in major cities, including Bandung face (Triwibisono & Aurachman, 2020). Bandung is a significant center of economic and social activity in Indonesia. However, rapid economic growth and an increase in the number of vehicles have led to worsening congestion in various parts of the city. Bandung has approximately 2.2 million vehicles, consisting of 1.7 million motorcycles and 500 thousand cars ('Syakura & 'Madani, 2023). This figure is almost equivalent to the city's population, which reaches 2.4 million people ('Syakura & 'Madani, 2023). This phenomenon creates serious city mobility and traffic congestion challenges (Duddy Studyana et al., n.d.). One area that frequently experiences congestion is Buah Batu Road. Traffic congestion problems tend to occur in areas with high activity intensity and extensive land use.

Buah Batu Road is approximately 1.70 km long and 13 meters wide (Duddy Studyana et al., n.d.). Its strategic location connects various areas, including toll roads, shopping centers, industrial zones, and residential areas, making it a primary choice for people to reach frequently visited places. This results in high traffic volumes on Buah Batu Road, leading to obstacles and reduced vehicle speeds (Duddy Studyana et al., n.d.)(Fadriani & Pirmansyah, 2022). However, due to its strategic role, Buah Batu Road also faces significant challenges in ensuring smooth traffic flow and preventing congestion, which can negatively impact Bandung's mobility and economy.

To illustrate traffic congestion caused by various obstacles that lead to increased density, refer to Figure 1. In this figure, four motorcycles are considered equivalent to one vehicle, and trucks are shown as the largest obstacles. Vehicles are categorized into two types: large vehicles and small vehicles. Large vehicles include trucks and buses with a length of more than 5 meters and a width of more than 2.5 meters, while small vehicles include passenger cars and motorcycles with a length of less than 5 meters and a width of less than 2.5 meters.

Previous research on traffic flow simulation has focused on density and speed but was less intensive and limited in the variables studied (Harry Gunawan, 2014). This study will expand the variables using the Upwind Scheme Simulation and the Decision Tree method based on Mean Squared Error (MSE) to model the relationship between density, speed, volume, and obstacles on Buah Batu Road. The results of this simulation will provide insights into traffic congestion and help find effective solutions.



Figure 1. Illustration of the observation area

This journal aims to explore and simulate a traffic flow model by approximating the velocity-density function derived from observational data.