DEVELOPMENT OF A REAL-TIME ROAD TRAFFIC ASSESSMENT TOOL FOR KIGALI CITY, RWANDA

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ABSTRACT

Traffic congestion is a significant problem in many urban areas, including Kigali City, Rwanda. This problem is associated with augmented fuel wastage, air pollution, financial losses, delays, and risk of accidents, due to poor traffic control and management. Traffic management efforts such as road widening, speed limit devices, and deployment of control measures to mitigate traffic congestion have not yielded expected results. This is largely due to limited availability of tools that incorporate real-time traffic flow parameters in road traffic assessment for metropolitan cities, such as Kigali. This study, therefore, developed a real-time road traffic assessment tool for Kigali City in Rwanda.

Purposive interviews were conducted with management officers of national roads in Kigali. Preliminary surveys of five national roads (NR1, NR2, NR3, NR4 and NR5) were carried out. Traffic volume data were captured on NR1 and NR2, between 5.00 a.m. and 8.00 p.m., for 30 days, between November 2019 and December 2019, as specified in the Highway Capacity Manual (HCM). Traffic patterns on NR1 and NR2 were analysed using regression models and Macroscopic Fundamental Diagram (MFD). A Traffic Assessment Tool (TAT) for real-time traffic flow analysis was developed based on MFD and regression models. The algorithm for real-time vehicle detection in TAT was designed and implemented using data captured on NR4. The data were analysed using descriptive statistics and t-test at $\alpha_{0.05}$.

The existing roadway, traffic and control conditions of the five national roads in Kigali City were found to be acceptable in accordance with the Rwanda Transport Development Agency Manual. Average daily traffic on NR1, NR2, NR3, NR4 and NR5, with the same design speed of 60 km/h, were 1030, 914, 867,780 and 885, respectively. Free flow traffic only occurred on NR2, with average flow rate of 645 veh/h. A clear transition between two flow regimes (free and congested) existed on NR1, with average flow rate of 1120 veh/h. Analysis of traffic on NR1 at free flow, yielded maximum flow of 3576 veh/h (5005.7 pc/h) (regression) and 3348 veh/h (4687.2pc/h) (MFD). These were greater than HCM recommended capacity of 3600 pc /h for two-lane roadways in a direction resulted in congestion. The critical density was 115 veh/km, which increased to a jam density of 230 veh/km in the congested regime. The mean accuracy of vehicle detection and tracking algorithms of TAT for NR4 was 92.7%. The real-time flow and critical density generated by TAT were 3492 veh/h and 106 veh/km, respectively. The highest coefficient of correlation ($R^2 = 0.2787$) between flow and density was obtained with MFD, which exhibited a better accuracy than the regression model. There was no significant difference between the flow parameters obtained from the field data and TAT.

The traffic assessment tool developed, provided real-time traffic analysis which could be combined with existing control systems to improve traffic management on national roads in Kigali City.

Keywords: Traffic Assessment Tool, Macroscopic fundamental diagram, Traffic flow, Kigali City

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