A GIS-based heavy vehicle noise emission model

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ABSTRACT
Prediction of road traffic noise is important for environmental impact assessments. In this work, a GIS-based heavy vehicle noise emission model is presented. The GIS-based model accounts for the influence of translational vehicle dynamics for a heavy vehicle on grade to enable accurate prediction of vehicle speed as well as operating conditions such as acceleration and deceleration. These kinematic variables in turn assist with accurate estimation of engine noise and rolling noise. To illustrate the model, a case study based on a freight route of the Great Western Highway in New South Wales is presented.

1 INTRODUCTION

Many communities in Australia regard heavy vehicles as the main source of traffic-noise induced annoyance and sleep disturbance (enHealth, 2018). This is attributed to distinctive features of heavy noise emission corresponding to the considerably higher maximum noise level than passenger cars, longer passage time, stronger low frequency content and the engine's characteristic modulation. The two main sources of noise emission of a heavy vehicle are engine noise associated with engine load and rolling noise generated at the interface between the vehicle tyres and road surface. Variation in road grade and vehicle speed also affects the contributions to the overall noise emission of a heavy vehicle (Jonasson, 2006; Peng et al., 2019). To accurately predict heavy vehicle source emission levels, a heavy vehicle noise emission prediction model that takes into account acceleration, deceleration and engine braking is required. In this work, a GIS-based heavy vehicle noise emission model is developed. Road geometry, road surface and traffic data are incorporated into the model. A case study based on a freight route of the Great Western Highway in New South Wales is presented.

2 SOURCE EMISSION MODEL

The source emission model was developed to predict noise emission within a road segment by considering road geometry, road surface, traffic volume, traffic composition and road signage. Figure 1 illustrates the framework of the source emission model. The initial input is geographic data generated by the SoundPLAN software. The road and traffic input modules of the source emission model are designed to create road geometric data (a coordinate reference system) and traffic data (vehicle type and count). The speed calculation module is designed to determine the vehicle speed and vehicle operation condition for the heavy vehicle based on the geometric data, traffic data and road signage of each road segment. The noise modules are then developed to predict the sound power level for each vehicle category by applying a series of adjustments to a reference sound level that is a function of the vehicle speed, vehicle operation condition and pavement type. Finally, the predicted sound power level is designed to be written in a shapefile format and to be imported into the SoundPLAN software for the sound propagation analysis.

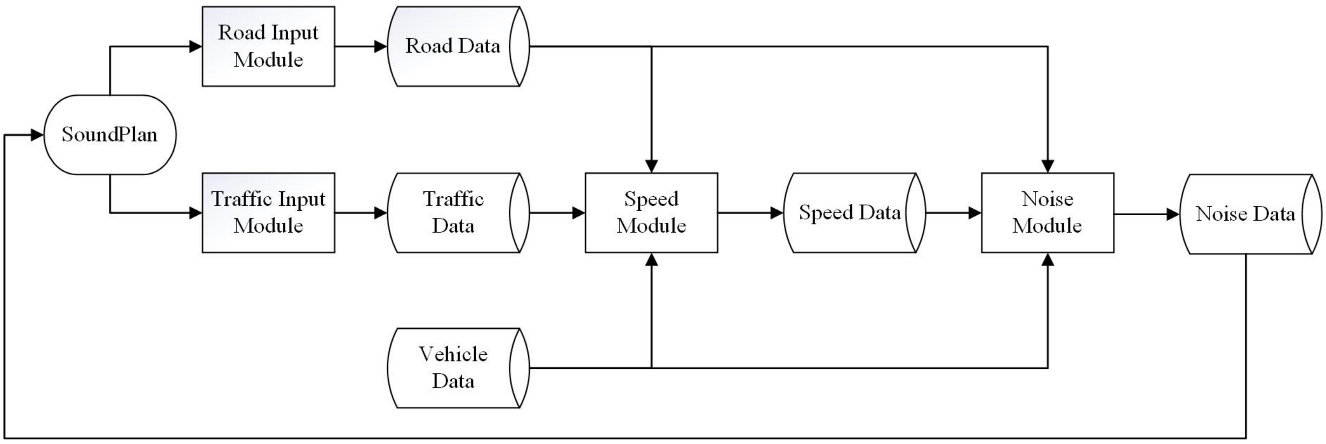

Figure 1: Framework of the source emission model.

3 CASE STUDY

A section of the Great Western Highway from Leonay (lower right corner of Figures 2-5 and denoted by point A in Figure 2) to Blackheath (upper left corner of Figures 2-5) was selected. The section of highway is about 57 km long, and discretised into 3190 road segments. A 9.7 kW/t 6-axle single-trailer truck traversing the highway with an approach speed of 30 km/h is used to illustrate the heavy vehicle noise emission model. Figure 2 presents the gradient per road segment and shows that the gradients for most road segments change from -5% to 5%. Two road sections with more than 5% gradient are marked as road section A and section B. Figure 3 shows computed speed profiles with a speed limit of 70 km/h. At sections A and B, the truck cannot maintain speed and decelerates rapidly to below 30 km/h. At all other road segments, the truck maintains vehicle speed between 50 km/h to 70 km/h. Engine noise sound power levels for each road segment shown in Figure 4 vary between 103 dB(A) to 111 dB(A). Rolling noise sound power levels shown in Figure 5 are above 106 dB(A) for most segments of road. The rolling noise decreases to approximately 100 dB(A) during both road sections A and B, which aligns with the reduced vehicle speed in these sections. Engine noise was found to dominate heavy vehicle noise emission on the uphill grade, with the contribution of rolling noise reducing rapidly as speed decreases on grade. Further work will also consider more case studies to investigate heavy vehicle noise emission, including engine braking noise and the duration of the sound exposure at receiver locations.

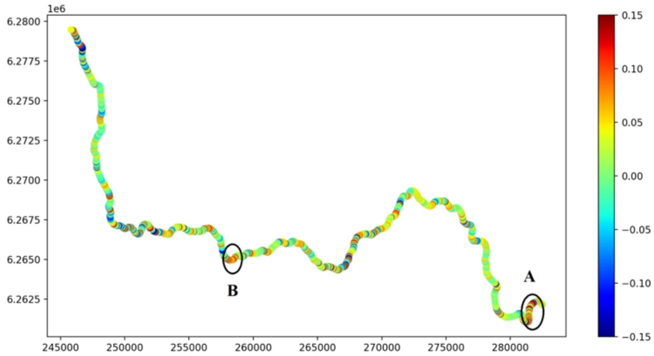

Figure 2: Gradient per road segment for the Great Western Highway

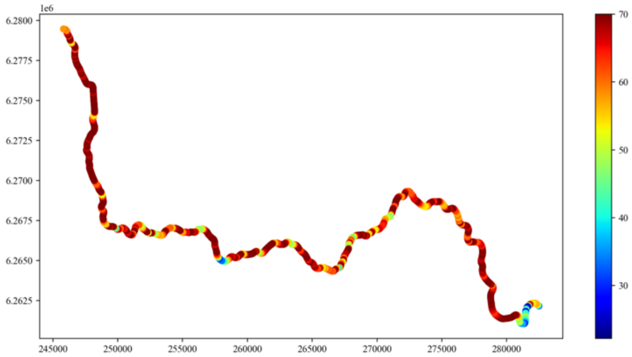

Figure 3: Mean speed (km/h) per road segment for the 6-axle heavy vehicle

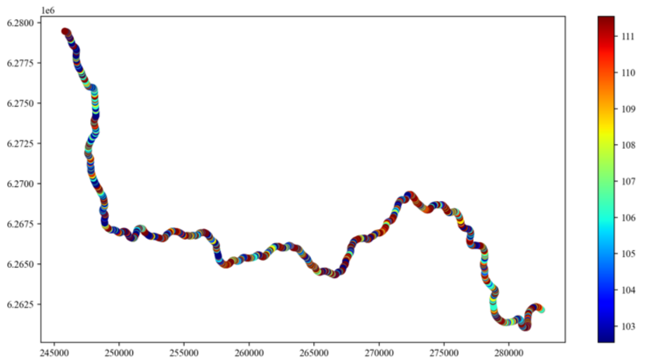

Figure 4: Engine noise sound power level (dB(A)) per road segment for the 6-axle heavy vehicle

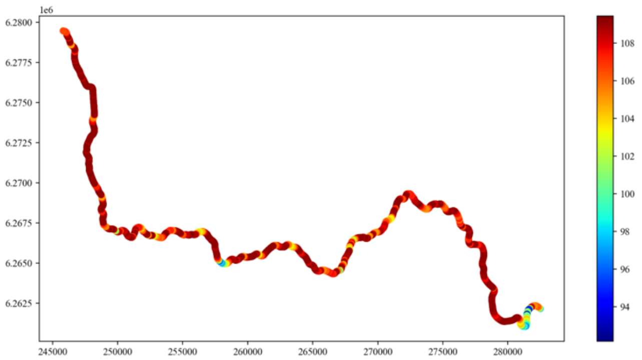

Figure 5: Rolling noise sound power level (dB(A)) per road segment for the 6-axle heavy vehicle

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