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Evaluation of Traffic Management Measures on Road Traffic Noise

Road traffic noise affects the quality of life in the areas adjoining the road. The effect of traffic noise on people is wide ranging and may include sleep disturbance and negative impact on work efficiency.
To address the problem of traffic noise, it is necessary to estimate the noise level. For this, a number of noise estimation models have been developed which can estimate noise at the receptor points, based on simple configuration of buildings. However, for a real world situation we have multiple buildings forming built-up area. In such a situation, it is almost impossible to consider multiple diffractions and reflections in sound propagation from the source to the receptor point. An engineering solution to such a real world problem is needed to estimate noise levels in built-up area.

Évaluation des mesures de gestion du trafic sur le bruit dû au trafic de routier

Les nuisances sonores dues au trafic routier affectent la qualité de vie des zones mitoyennes. Les effets de ce bruit sur la population sont largement rependus et peuvent entrainer des troubles du sommeil et des impacts négatifs sur la productivité professionnelle.
Pour attribuer ces problèmes au bruit du trafic, il est nécessaire d'estimer ce niveau de bruit. Pour cela, de nombreux modèles, permettant l'estimation du bruit en un point donné en tenant compte d'une configuration simple de bâtiments, ont été développés. Néanmoins, pratiquement, nous rencontrons des zones constituées de nombreux bâtiments et obstacles. Dans cette situation, il est quasiment impossible de considérer les multiples dispersions, diffractions and réflexions lors de la propagation d'un son d'une source jusqu'au point de réception. Pour ce genre de problèmes réels, une solution doit est développer pour estimer le niveau sonore dans les zones construites.

From Ashish Bhaskar, Edward Chung and André-Gilles Dumont *

Areawide noise prediction models generally do not consider time dependent traffic demand so; they fail to consider inbuilt dynamic traffic characteristics. Moreover, the models generally do not predict noise over both space and time. In order to impose effective and cost efficient transportation policy, especially noise abatement policy, it is necessary to understand the variation in traffic noise levels on both, spatial and temporal scale.
To fulfil the above mentioned needs, we have developed, areawide Dynamic ROad traffic NoisE (DRONE) estimation software tool [1], which can:

- Estimate road traffic noise levels in built-up areas, taking buildings affect into account and;
- Provide areawide dynamic road traffic noise contour maps (i.e. road traffic noise prediction over both space and time).

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DRONE is developed as a research project at the University of Tokyo, Japan. It is a useful tool for studying the effect of different transportation management and infrastructure policies on the variation in road traffic noise level over a large urban network.

Noise reduction in an urban area can be achieved by noise abatement policies. However, policy applied on one area can affect the other area. To study such phenomena, it is necessary to consider the variations in noise levels on an areawide region. DRONE estimates the number of buildings affected by different noise levels and can easily display them in the form of noise contour maps. The different scenarios can be incorporated and investigated in order to study the areawide variation on noise level and its effect on different areas, even before the implementation of the policy.

This paper discusses about the importance of integrating traffic assignment and noise prediction models through a case study on a real urban network (3 km by 5 km) around Ikegami Shinmachi intersection at Kawasaki city, Japan. First, the model development is discussed followed by the case study.

Model Development

DRONE is developed by integrating traffic simulation model, AVENUE [2] with Japanese road traffic noise estimation model, ASJ-1998 Model [3], which is further linked with GIS to provide areawide dynamic road traffic noise contour maps (Figure 1). The model has been verified, validated and applied on a real world situation [1].

ASJ-1998 Model, is the standard road traffic noise estimation model, developed by Acoustic Society of Japan (ASJ), and is used for environmental impact assessment in Japan. It estimates the equivalent continuous A-weighted sound pressure level according to the energy based calculation. Precise calculation of multiple scattering, diffraction and reflection, is practically very difficult in built-up areas. The problem is approached by statistical methods to estimate noise level in such areas, the details of which can be found in [1].

The coding of DRONE is written in object oriented framework (C++) which features the system with a high flexibility to modify or extend its functions. Present version of DRONE estimates noise based on Japanese ASJ-1998 Model, and it is planned to incorporate other noise predication models, such as, Swiss StL-86 and SonRoad model.

It is to be noted that DRONE can utilize the output of any traffic simulation models. For example, vehicle trajectories from microscopic traffic simulator, such as, AIMSUN can be processed into a format suitable for DRONE.

Case Study

To study the affect of different noise abatement polices; DRONE is applied on a real world network around Ikegami Shinmachi intersection at Kawasaki

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city, Japan. This area is notorious for both air and traffic noise pollution. Different transportation and noise abatement policies are applied on a 1 km by 1 km area around Ikegami Shinmachi intersection (CORE area). To study the effect of the policies the study area is extended to a bigger area of 3 km by 5 km around Ikegami Shinmachi intersection (WHOLE area) (Figure 2). In the Figure 2, the diagonal road is a local highway with residential area on the left and industrial area on the right.

The different transportation and noise abatement policies which are evaluated in this study are: use of noise reducing infrastructure (such as sound wall and drainage asphalt pavement); and traffic management (such as banning of heavy vehicles and imposing speed limits on the vehicles). In this paper, only contour maps dealing with the banning of heavy vehicles are presented and finally a comparative overview of all the scenarios is discussed.

Figure 3 represents the noise contour map which corresponds to the present situation (BASE CASE). In the contour maps, all blue regions, represent regions having noise level below threshold noise level, which is 55 dB(A) for residential area and 60 dB(A) for industrial area. All non blue regions, are regions above threshold noise level and are classified as affected regions (for BASE CASE, the percentage of residential and industrial buildings affected in CORE area is around 16% and 18% respectively; and for WHOLE AREA the corresponding percentages are around 16% and 17% respectively). The scenario of banning of the heavy vehicles along the highway section (as indicated in Figure 4) may lead to the detour of the vehicles along the arterial route. This results in the decrease of noise level along the highway section, but corresponding increase in the noise level along the arterial route. As can be seen, the arterial roads which were less intense in the BASE CASE (Figure 3) are more intense in Figure 4. The same is reflected in terms of change in percentage of buildings affected. There is a decrease in percentage of buildings affected in the CORE area (the percentage of residential buildings affected in CORE area has decreased from 16% to 15% and industrial buildings affected have decreased from 18% to 16%) but the problem has shifted to the WHOLE area (the percentage of residential buildings affected in WHOLE area has increased from 16% to 18% and industrial buildings affected have increased from 17% to 18%; Figure 5).

The scenarios dealing with traffic management may lead to detour of vehicles not only on spatial scale but also on temporal scale. The effect of these scenarios on the dynamic road traffic noise in an areawide region can only be achieved by the integration of the traffic assignment model with noise prediction model. Figure 6, provides a comparative overview of the different measures relative to noise reduction and cost of installation and maintenance of the measures. Noise level reduction is high if we have a noise reducing infrastructure such as sound wall or drainage asphalt. However, such measures require a significant amount of investment and maintenance. On the other hand, managing traffic requires less investment, but the problem from one area may shift to other areas. Policy makers may assign different weights to different scenarios and based on multi criteria analysis they can provide a cost effective and efficient road traffic noise abatement policy and tools, such as, DRONE should prove to be very effective to the policy makers.

Conclusion and Future Research

To conclude we can say that the DRONE can be applied on any areawide traffic network to estimate noise at any number of receptor points and to generate areawide dynamic noise contour maps. When applied on an areawide region it can:

- estimate the number of buildings which are above the threshold noise levels and can identify spots where the noise level exceeds the national standards.
- study merits and demerits of noise abatement policies based on cost efficiency and effectiveness.

The results from DRONE can also be applied to quantify social affects associated to noise pollution and for strategic planning.
Present version of DRONE estimates noise based on Japanese noise model. The extension of DRONE to Swiss conditions and Swiss noise model is in progress. ■

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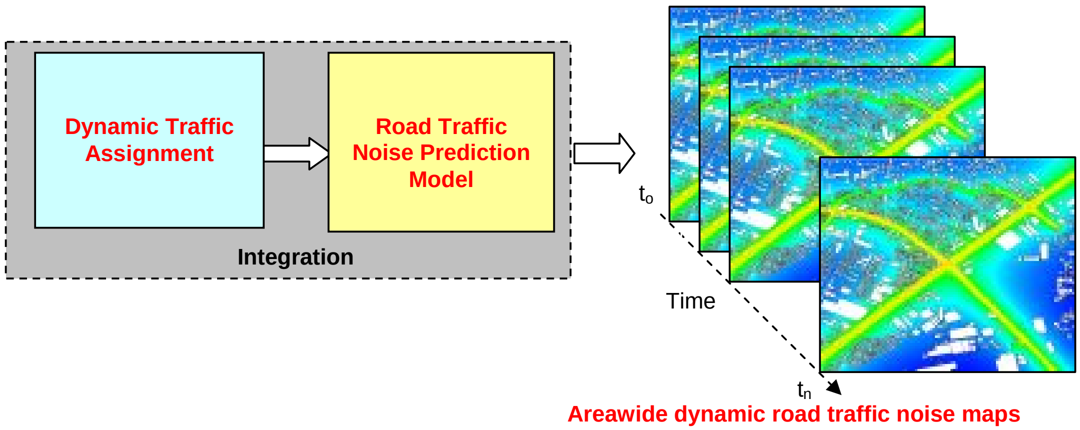
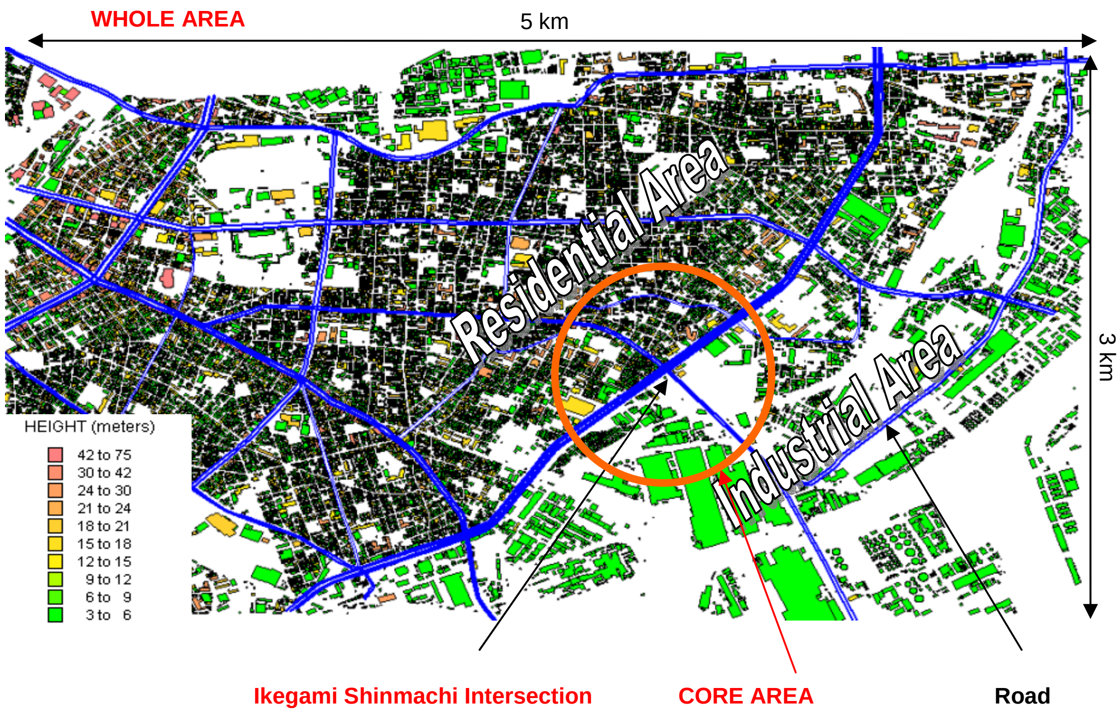


1: Framework for DRONE

1: Cadre général de DRONE



2: Definition of CORE and WHOLE areas. Blue lines represent roads and building height is represented by different colours.

2: Définition de la CORE et de la WHOLE zone. Les routes sont représentées en bleu et la hauteur des bâtiment est indiquée par differentes couleurs.

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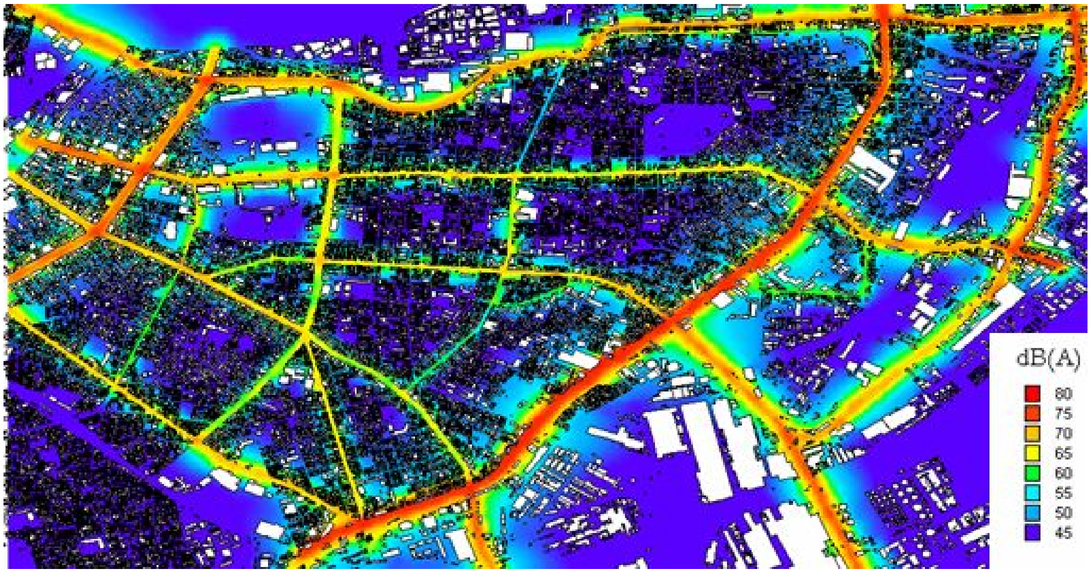

3: BASE CASE Contour Map, corresponding to present traffic conditions.

3: La carte de repartition de la SITUATION de BASE, correspondant au trafic actuel.

4: Contour Map when heavy vehicles are banned on the highway section as indicated

4: Carte de découpe correspondent au cas où véhicules lourds sont interdits sur la section de route indiquée.

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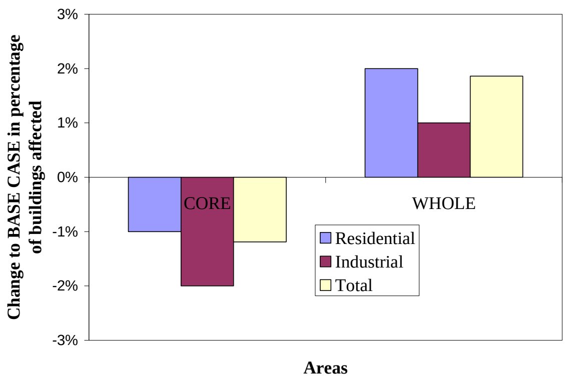

5: Percentage of buildings affected for CORE and WHOLE areas relative to BASE CASE

5: Pourcentage des bâtiments affectés, par rapport au cas de BASE, de la zone CORE et de la zone WHOLE.

Measure	**Noise Reduction**		**Cost**	
	CORE Area	**WHOLE Area**	**Installation**	**Maintenance**
Sound Wall	HIGH	HIGH	HIGH	MEDIUM
Drainage Asphalt	HIGH	HIGH	HIGH	HIGH
Restrict Heavy Vehicles	MEDIUM	NEGATIVE IMPACT	NIL	NIL
Impose Speed Limit	NEGATIVE IMPACT	NEGATIVE IMPACT	NIL	NIL

6: Comparative overview of different measures related to noise reduction and cost of installation in CORE and WHOLE areas

6: Vue d'ensemble comparative de la réduction du bruit et du coût d’installation pour différentes mesures dans la zone CORE et la zone WHOLE