Visualization of Complex Noise Environment by Virtual Reality Technologies

LAW Chi Wing, LEE Chee Kwan and TAI Moon Kwong
Environmental Protection Department

Abstract

Continuous public involvement is one of the critical elements for a successful Environmental Impact Assessment (EIA) Process. For an effective public engagement, the public's understanding of environmental noise information is essential and it is very critical to present such information in such a way that it is easily understood and digested by the general public. The traditional two-dimensional presentation approach by means of tables and numerical figures on maps would not be easily understood by the general public, especially for a project in a complex high-rise metropolis like Hong Kong. Even professionals such as environmental consultants or engineers do need some time to digest the huge amount of information. This paper describes a three-dimensional (3D) noise assessment tool using geographic information system (GIS), 3D digital model technology and large-scale noise model application to facilitate the technical information presented in a more layman way for easy public's understanding. This would provide a 3D interactive virtual reality environment, for the viewer to walk and fly through the 3D space to grasp the noise information. The virtual reality can serve the public and professionals by providing a user-friendly 3D tool for understanding noise impacts of various planning options and effectiveness of mitigation measures at the initial stage of planning. The public can navigate the virtual space, recognise their familiar vicinity and appreciate the future noise environment of different project options and different forms of mitigation measures instantly.

1. Introduction

Hong Kong has one of the most transparent environmental impact assessment (EIA) systems in the world. Environmental assessment is applied not only to individual projects, but also to strategic policy and proposals, making it a valuable tool in moving towards a more sustainable path of development. An EIA can be more successful with continuous public involvement. The views from the public should be adequately considered during the whole project progress. Hence, the information conveyed to the public should be easily understood and digested so as to achieve an efficient and effective public involvement process.

In noise impact assessment, information such as the layout plans, location of noise sensitive receivers (NSRs) and predicted noise levels are traditionally presented by means of

figures and tables. However, the public, non-professional and even professionals may sometimes find difficulties in grasping the information contained in the complicated figures and tables and so figuring out the future noise environment virtually.

This paper illustrates how to utilise the GIS, 3D computational model and virtual reality (VR) technology to help the public to "visualise" the complex noise environment.

2. Traditional two-dimensional presentation approach

During the EIA process, the project proponent should prepare an EIA report consisting of noise impact assessment to demonstrate the anticipated noise impact at representative NSRs in different scenarios. The future road alignment, locations of NSRs, and assessment results with and without mitigation measures are generally presented on maps and in tables as shown in Figure 1.

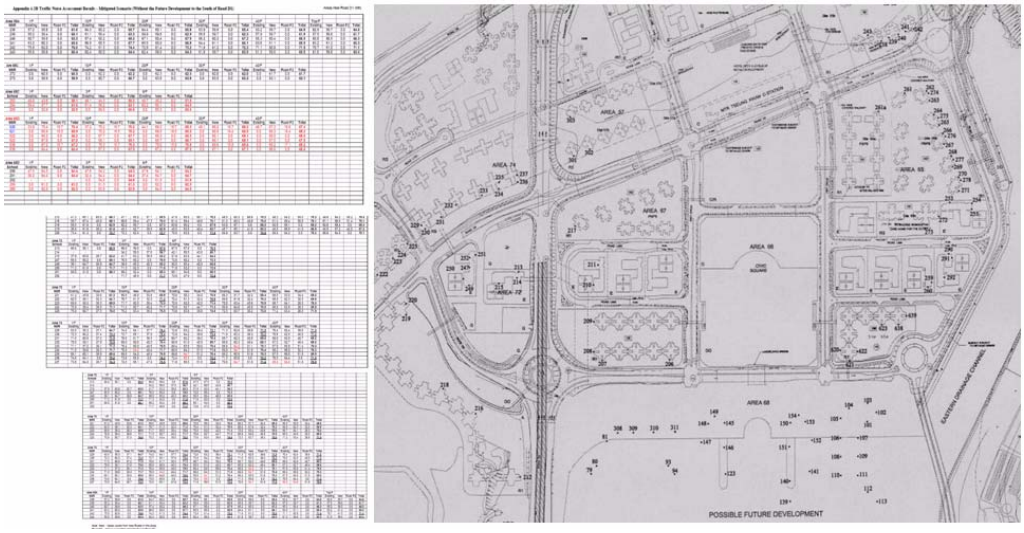

Figure 1 Noise assessment results presented on maps and in tables

To better present the noise environment for the public, the Environmental Protection Department (EPD) developed a GIS based territory-wide noise modeling system and prepared traffic noise exposure maps for the whole territory of Hong Kong. A typical map is given in Figure 2, giving a clear picture of the noise distribution and illustrating how the road traffic noise impact affects the nearby buildings.

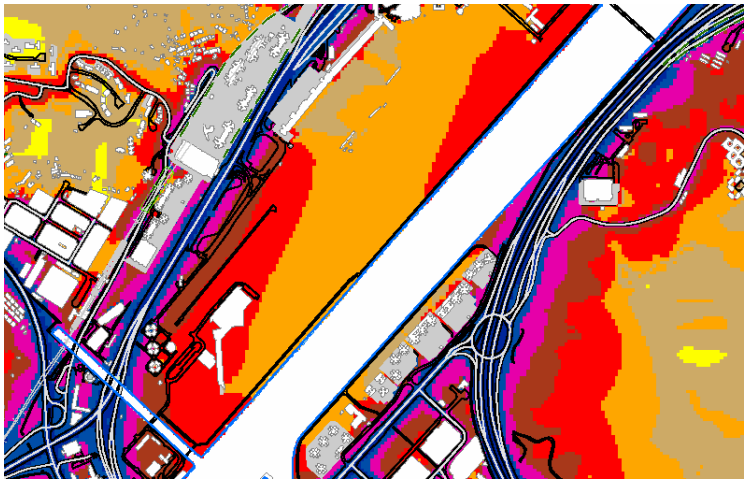

Figure 2 Noise exposure map; contour colours represent ranges of noise level

Due to compact environment with numerous high-rise buildings, road networks, complex terrains and elevated structures in Hong Kong as shown in Figure 3, the public and the non-professionals may not easily understand the existing and the future scenario solely based on a 2D layout plan. They may have difficulties in linking up the predicted noise level results between the maps and dozens of the tables, especially when there are hundreds of NSRs spreading over some complex environment packed with high-rise buildings, low-rise village houses, local roads, major roads and railways, etc.

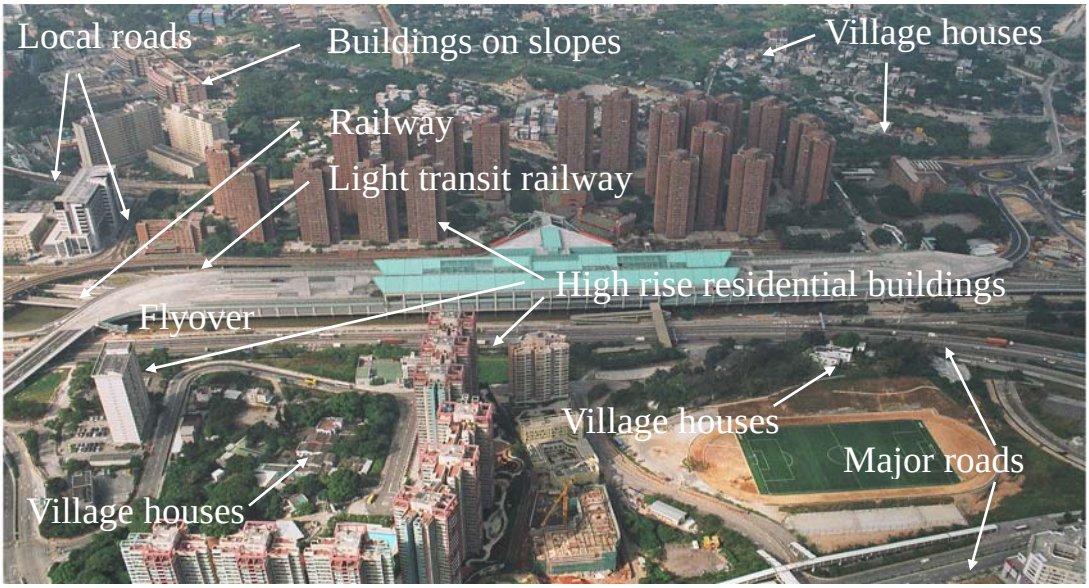

Figure 3 Complex metropolitan in HK

3. 3D visualization

To further describe the 3D complex noise environment to the general public, EPD has prepared the photorealistic 3D noise models to facilitate the public to understand the noise

environment. It comprises of 3 modules, these are the basic 3D model, the computational simulated façade noise grid model and the photorealistic 3D model in the urban area.

3.1. Basic 3D Model

The 3D model is developed according to the GIS data for buildings, roads, terrain, podiums and barriers. GIS data on buildings, barriers, road segments and terrain have also been used for computational noise level prediction, as well as forming the skeleton of the 3D model. An example showing the view when looking from one side of the harbor is shown in Figure 4. Undoubtedly, the model is comparatively easier for the people to recognize in due regards of the traditional “table and map” approach.

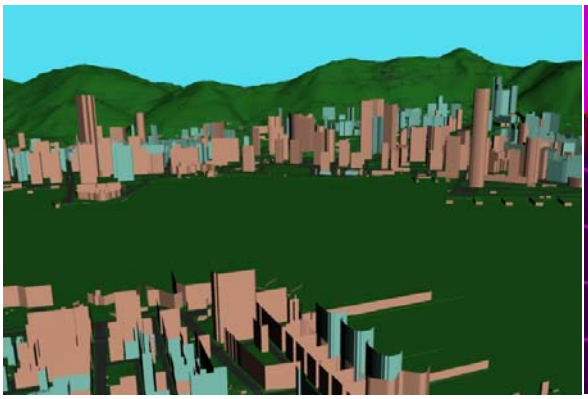

Figure 4 3D model of HK harbour area

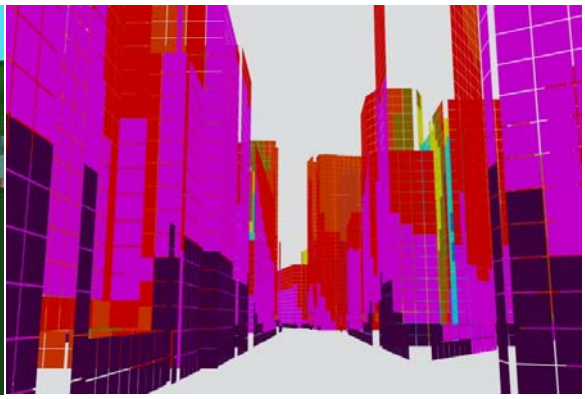

Figure 5 Façade noise grids presented in 3D format

3.2. Façade noise grid model

The GIS data mentioned above provided by various government authorities have been used to calculate the noise level at the building facades. Employing the procedures in the ‘Calculation of Road Traffic Noise (CRTN)’ and the large scale noise mapping software, having considered the traffic composition, flow, speed, the noise propagation, reflection, screening, ……etc., a 3D noise grid model has been generated and shown in Figure 5. All the 3m by 3m noise grids are located vertically one metre from building façades, and their colours are categorized according to the calculated noise levels, indicating the traffic noise distribution on the façade of buildings. Through this model, the people can easily understand the location of the most and least noise affected areas in 3D view at a glance.

3.3 Photorealistic 3D models

It is a very direct initiative that people can best grasp the future surrounding environment when they can see it in a “real” world. To generate a “real” world, image textures are mapped to produce photorealistic models. Aerial photos are used for landscape mapping, and road segments were furnished with road textures and road furniture. The commercial buildings and residential buildings are mapped with different sets of generic photo textures. Some landmark buildings are erected with actual building texture images to help the public to recognize the “real” location. Figures 6a and 6b show the results of the photorealistic 3D model of the harbour area. Figure 6b further shows a close up of buildings, indicating people can select different viewpoints around the harbour.

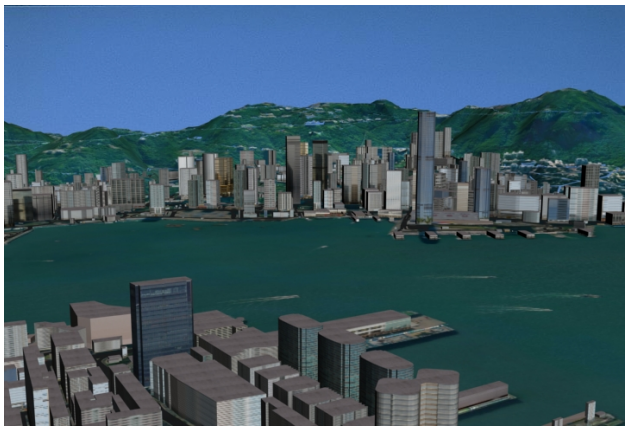

Figure 6a

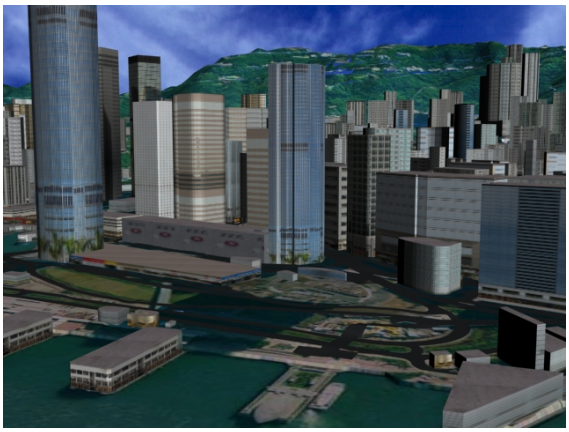

Figure 6b

Figures 6a & 6b Photorealistic 3D model of the harbour area of HK

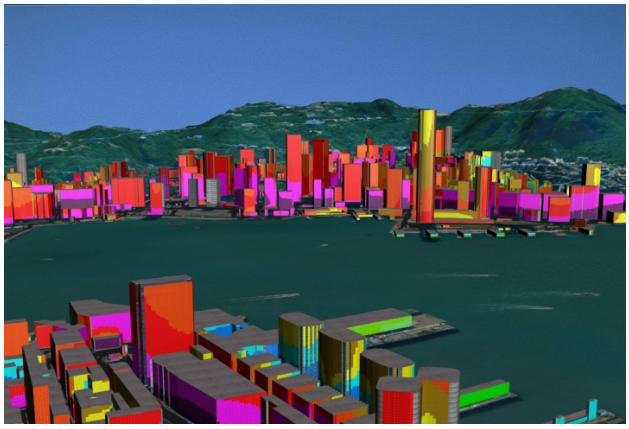

Figure 7a

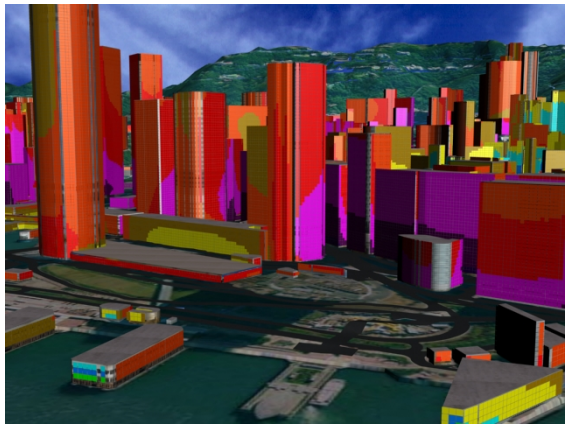

Figure 7b

Figures 7a & 7b Photorealistic 3D model with noise facades of the harbour area of HK

Figures 7a and 7b show the 3D noise grid model covering the photorealistic models to illustrate the noise environment. The façade noise grids have been linked with the photorealistic models and can be turned on and off to avoid obstructing the view when identifying the location of the concerned area. The users can fly and walk through the virtual environment using the mouse. This provides a better platform for the understanding of the noise environment.

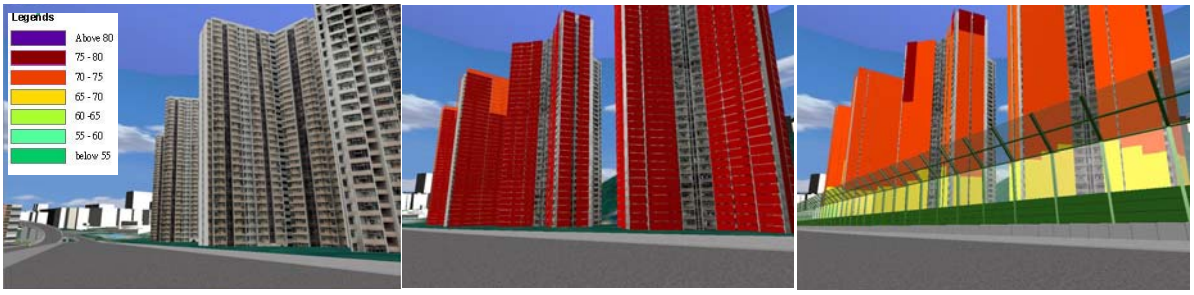

Figure 8a Current situation *Figure 8b Unmitigated scenario* *Figure 8c Mitigated scenario*

Figures 8a, 8b and 8c Photorealistic 3D models showing different scenarios

Figures 8a, 8b and 8c show the photorealistic 3D models of Tseung Kwan O (TKO) Road and the façade noise grids in unmitigated and mitigated scenarios, respectively. Users can identify the predicted noise level at a particular flat and location or observe the changes in noise level at different heights or scenarios. By presenting the noise information, mitigation measures incorporating with the realistic 3D model, noise environment can be easily appreciated by the public or non-professionals and they will see to believe. The 3D visualization tool has been used to present the performance of retrofitting barriers on TKO Road to Kwun Tong District Council on October 2005 as part of the consultation process. The Councilors were well impressed by the works and the consultation went very smoothly.

In order to facilitate the viewing and surfing of the photorealistic models by the general public via the Internet, all the models are exported in the format of virtual reality modelling language (VRML) (ISO/IEC, 1997). This is a standardized 3D programming language likes a common web page, where the developed models can be browsed in a general Internet browser after installing a free downloaded VRML plug-in. Some conversion tools have already been launched in EPD website to help the other professionals to convert most of their existing noise models to simple VRML model for viewing.

4. Enhanced visualization by immersive virtual reality tools

The application of VRML in presenting the 3D photorealistic noise models provides a useful tool for the general public to view the noise environment through the Internet. To provide the general public a good perception in the depth of view and to let first-time users to master the control, EPD has developed a comparatively user-friendly visual and control interface, which is the immersive visualization system. The system is capable of generating an immersive VR environment to illustrate the acoustical environment. The following equipments are used:

(a) Two Digital Light Processing (DLP) projectors with Polaroid producing stereo images;
(b) Silver screen displaying the polarized 3D images;
(c) Polarized glasses for viewing the immersive VR environment;
(d) Game pad for manipulating within the immersive VR environment; and
(e) Personal computer with dual display ports giving dual signals to the projectors.

The two DLP projectors deliver a pair of similar images with slight path differences so that the viewer can “see” the 3D environment when viewing through the polarized glasses. Stereoscopic view of the images can provide the users better sense of depth. The user-friendly game pad with simple function keys including the forward/backward/up/down movement, left/right rotation, and up/down tilt buttons, allows the users to walk and fly through the virtual environment freely even for first-time users. Figure 9 demonstrates a user wearing the polarized glasses, using the game pad and flying through the immersive VR environment.

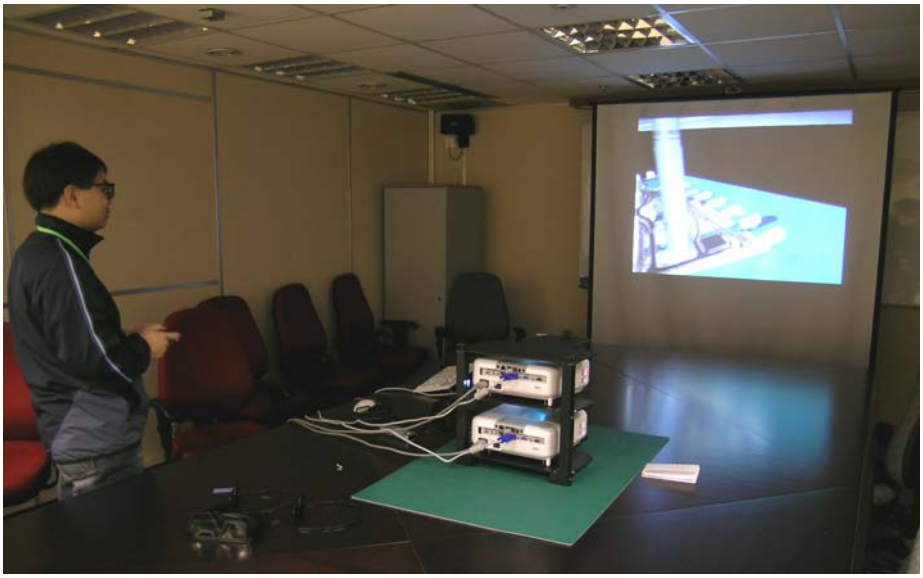

Figure 9 Using polarized glasses and game pad to play the immersive VR system

5. Conclusions

It is useful to integrate 3D GIS and 3D interactive web based VRML format to help the public, from professionals to laymen, to quickly appreciate the noise level distribution in the compact and complex metropolitan and urban settings. With the development of photorealistic 3D noise models and the adoption of virtual reality tools, VRML models or Immersive VR tools, illustrating the noise environment in 3D format, even general public and non-professionals can easily understand the current and future noise environment. It provides the public with a better appreciation of the complex noise environment, an easier method for identifying noise impact at certain receivers, and better means to understand the noise distribution in different scenarios of a project, and hence, beneficial to the enhancement of continuous public involvement

The immersive virtual reality tools allow users to “see” and “walk” through the noise environment themselves as in the “real” world. Currently, Department of Geography and Resource Management in The Chinese University of Hong Kong and EPD are making effort to add audio effect to the immersive virtual reality tools. In this way, the public not only can visualize the existing or future VR noise environment but hear it as well.

References

ISO/IEC 14772-1:1997 “Information technology – Computer graphics and image processing – The Virtual Reality Modelling Language (VRML) – Part 1: Functional Specification and UTF-8 Encoding.”