© Nottingham University Press
Proceedings of the International Conference on
Computing in Civil and Building Engineering
W Tizani (Editor)

An approach to represent air quality in 3D digital city models for air quality-related transport planning in urban areas

El-Said M Zahran, Lloyd D Bennett & Martin J Smith
Faculty of Engineering, The University of Nottingham, NG7 2RD, UK

Keywords: transport schemes, air pollution modelling, 3D city models, interface

The growth of urban traffic levels is associated with a broad range of problems such as traffic congestion, air pollution, traffic noise, reduced accessibility and community severance. However, tackling the traffic congestion is deemed the main contributor to resolving the other traffic growth-related problems (NCC and NCC, 2006). Many urban transport schemes developed by local authorities involve changing the physical infrastructure to improve the traffic flow and/or to encourage the use of alternatives to the private car, in order to reduce traffic congestion and to reduce the other problems resulting from traffic growth, such as worsening air pollution.

Air pollution dispersion modelling may be used to model the air quality impacts of the implementation of proposed urban transport schemes. Visualisation of air quality, both before and after scheme implementation, should help transport planners and decision-makers to select the transport scheme alternative that maximises the air quality benefits and/or minimises the adverse air quality impacts. In addition, having an intelligible visualisation of these air quality impacts may be helpful in the public consultations which are nowadays an increasingly important part of the planning and decision-making processes. Currently, the results of air pollution dispersion modelling are usually displayed by overlaying 2D coloured contour maps of the air pollution concentrations over 2D digital maps of the interest area in a Geographic Information System (GIS), which may not be all that intuitively meaningful for all the different people who constitute the participants in the public consultations about proposed urban transport schemes.

Furthermore, using the traditional 2D contour maps to recognise the change of pollution concentrations with height requires the creation of many scenes, one at each height. That has the potential to confuse the observer of such a large number of 2D scenes and to impede obtaining a good understanding of the changes in pollution concentrations with height. Therefore, the 3D visualisation of various air pollution concentrations at and above the ground surface in a single 3D virtual scene may achieve improvements in relation to two important factors regarding Human-Computer Interaction (HCI), namely increased information retention and shortened comprehension time (Sears and Jacko, 2008).

Therefore, modelling research has been done to integrate ADMS-Roads, an air pollution model, with a 3D digital city model of Dunkirk Air Quality Management Area (AQMA), an urban study area in the city of Nottingham with NO_2 levels exceeding the permissible levels, to seek to create an effective 3D air pollution dispersion interface which can be appreciated intuitively. Hence this research has been working with the idea of showing the air pollution as grey clouds, using ordinary people's (negative) perceptions of grey clouds representing poor weather: the darker are the clouds, the worse is the weather. As a case study, the interface has been applied to attain a 3D visualisation of future air quality impacts of a proposed urban transport scheme, the introduction of a (largely elevated) section of Nottingham Express Transit (NET) Phase 2 running through the Dunkirk AQMA. NET is a modern urban tram system which, as the network of tram lines develops, should provide an attractive alternative to the car for more and more urban trips in Nottingham (NCC and NCC, 2006).

ADMS-Roads version 2.3 was used to output NO_2 concentrations, as numerical values, at a grid of receptors covering the Dunkirk AQMA. ADMS-Roads was developed by Cambridge Environmental Research Consultants (CERC, 2006). The first reason for selecting NO_2 was that the air pollutant of concern in the Dunkirk AQMA was NO_2. Therefore, the majority of available air pollution monitoring data, required to validate the air pollution model, in and around Dunkirk AQMA was NO_2 data. The second reason for selecting NO_2 was that NO_2 is emitted primarily from the road traffic. Therefore, some modal shift from the private car to NET Phase 2 is anticipated to reduce the high NO_2 levels in the Dunkirk AQMA (NCC and NCC, 2006).

The 3D city model of the Dunkirk AQMA was designed so that smooth navigation through could be attained while maintaining a good level of location recognition and orientation. The development of this 3D city model required the real integration of CAD and virtual reality, which was identified as a challenge by Whyte et al. (2000), to represent a dynamic traffic layer and the road network features in the Dunkirk AQMA 3D city model. These representations improved the location recognition and orientation and compensated for not representing the residential buildings in 3D in the Dunkirk AQMA 3D city model; were these residential buildings represented in the 3D city model, they would obscure the air pollution within and underneath. In addition, such integration between CAD and virtual reality enabled the representation of the physical infrastructure of NET Phase 2 running through the Dunkirk AQMA 3D city model which created a contrast between the present and future additional infrastructure.

In this research, two different 3D point array interfaces were created to represent NO_2 concentrations at and above the ground surface in a single virtual scene, which was identified as a challenge by Wang et al. (2008). However, these two developments were found not to be particularly intuitively meaningful, so the research was progressed further to the representation of the NO_2 concentrations by 3D volumetric clouds which, given the analogy with weather clouds mentioned above, may assist human visualisation of air pollution.

References

CERC, 2006. ADMS-Roads Version 2.2 User Guide. *An Air Quality Management System.* Cambridge Environmental Research Consultants Ltd.

NCC and NCC, 2006. Local Transport Plan for Greater Nottingham 2006/7 to 2010/11. Nottingham City Council and Nottinghamshire County Council.

SEARS, A. and JACKO, J. A., 2008. *The Human–Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*, Lawrence Erlbaum Associates.

WANG, X., SHI, J. and HUANG, H., 2008. Traffic-related air quality analysis and visualisation. *Civil Engineering and Environmental Systems,* 25**,** 157 - 166.

WHYTE, J., BOUCHLAGHEM, N., THORPE, A. and MCCAFFER, R., 2000. From CAD to virtual reality: modelling approaches, data exchange and interactive 3D building design tools. *Automation in Construction,* 10**,** 43-55.