Application of 3D Computer Animation in Road Design in the Highways Department

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Key words: computer animation system, road alignment design, digital terrain.

SUMMARY

Public consultation becomes one of the essential tasks for the successful implementation of a highway project. Traditional design drawings containing line-works and numerical data are not readily understood and become an ineffective tool in communicating with members of the general public. The Highways Department of the Government of the Hong Kong Special Administrative Region (HKSAR) introduced photogrammetry based 3-dimensional computer animation system in 2001 with an aim not only to facilitate the engineers in road design and assessment of the environmental impacts but also to enable the public to better understand and visualize the final appearance of the road project. This paper attempts to discuss how the system was developed and applied in some of the major highway projects and the experience learned.

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1. ABSTRACT

Public consultation becomes an essential task for the successful implementation of every major highway project. Traditional highway design software produces only design drawings which contain a lot of numerical data and line-works, and cannot be readily understood by the public. To enable the public to better understand the highway project, the Highways Department of the Government of the Hong Kong Special Administrative Region (HKSAR) introduced photogrammetry based 3-dimensional computer animation system in 2001 with an aim not only to assist the engineers in the road design and environmental impact assessment but also to enable the public to visualise the final appearance of the road project. This paper discusses the development and application of the system in the Highways Department and the experience learned.

2. INTRODUCTION

The Highways Department of the HKSAR Government is responsible for the planning, design and maintenance of Hong Kong's public road system and for coordinating the implementation of new highway and railway projects. In the past, the Highways Department carried out the design of public roads using traditional software, mainly Bentley MX Road and Microstation. These software applications have served the professionals well in the past by enabling them to efficiently discharge their design responsibilities, e.g. to derive the costs and benefits of different alignment alternatives, to ensure that the proposed highway meets the required design standards in respect of gradient, superelevation etc, to minimize the volume of earthworks and the associated cost, and to design the associated road drainage, lighting etc.

While the traditional software applications serve the professionals well, there remains a wide gap in meeting the needs of an important class of stakeholders - the public. The public cannot readily understand the results and outputs of these tools, which are generally in the form of plans and sections with a lot of numerical data. Furthermore, the public needs to visualize the proposed highway from their own perspectives: how the highway would look like upon completion, what would be the driving experience, what are the potential impacts to the surrounding environment such as visual impact and noise impact and whether the mitigation measures proposed are effective.

To address the above concerns, the Highways Department acquired the 3-dimensional computer animation system (CAS) in 2001.

3. THE COMPUTER ANIMATION SYSTEM

3.1 System Components

The Highways Department introduced the use of photogrammetry based 3-dimensional computer animation system for highway projects in 2001. With the increasing demand for virtual reality model for feasibility studies and project presentations, the Highways Department upgraded the system in 2005. The configurations of the system currently in use in the Highways Department are HP Workstations with stereoscopic viewing devices and a 3-dimensional data capturing device, Dual Intel Xeon Processors with 3.6GHz CPUs, 4 GB DDR2 RAM, 800 GB internal SATA hard disk.

The computer animation system comprises the following major application software:

(i.) VirtuoZo NT Classic
(ii.) Leica Socet Set
(iii.) Autodesk Viz 2007
(iv.) Autodesk 3DS Max
(v.) Adobe Premiere Pro
(vi.) Turbo squid RTRE

3.2 Data Process

The computer animation system requires the following typical input data in order to produce the photo-realistic animations for a highways project:

3.2.1 Design data of the proposed highway

The detailed design of the road alignment basically follows the criteria and requirements as stipulated in the Transport Planning and Design Manual issued by the Transport Department of the HKSAR Government.

The detail road alignment design is handled by the survey sections in the Highways Department. They used MX Road for the horizontal and vertical road alignment designs, checking of crossfall, computation of earthwork quantity, and generation of drawings and reports. Based on the ground survey model which is formed by series of string of field survey data, the MX Road superimposes the road design alignment model onto the ground model. The output can be in the form of string feature, triangulated road design model, cut and fill slope interface and etc.

3.2.2 Digital Terrain Model

For creation of the existing terrain model, the Highways Department uses two photogrammetry software packages: Leica Socet Set software and VirtuoZo. Both software packages are commonly used for creation of terrain and building models and capturing of 3-dimensional data from aerial photos by photogrammetry surveying techniques. The software

can also be used for producing orthophoto for capturing texture information from the aerial photos for the terrain model.

In the past, we spent a lot of time to produce orthophotos from the aerial photos by photogrammetry techniques. In recent years, the Lands Department of the HKSAR Government developed a new product called digital orthophoto map at a scale of 1:5000. These orthophoto maps are generated based on aerial photos taken from 8000 feet height at about 1 to 1.5 meters ground resolution. For applications which do not require high resolution, the orthophoto maps provided by the Lands Department are generally sufficient for capturing texture mapping information.

3.2.3 Three Dimensional Object

To generate photo-realistic animation, we need to create a large number of 3-dimensional static and moving objects to model the real situation. These objects include 3-dimensional buildings, trees and street furniture items such as lamp posts, fire hydrants, sign gantries, railing as well as moving objects like pedestrians and vehicles.

In the past, we spent a lot of time to create 3-dimensional objects for each computer animation project. To improve efficiency, effectiveness and productivity, we have established a centralised inventory library of common 3-dimensional objects from which users can select suitable objects for use in their own projects. On the other hand, objects created for each project are screened for their suitability for inclusion in the library, and where appropriate, these objects are enhanced (e.g. by reducing unnecessary model faces and structures, improving the surface image format, and reducing their size) before being registered into the library. Now the inventory library contains over 380 objects under the following categories:

Category	Sub-category	Code	Features created
Street Furniture	Lamppost	LP	9
	Signpost	TS	73
	Signboard	SB	3
	Miscellaneous	SM	5
Tree & Plant	-	TR	2
Vehicle	Private	VR	3
	Public	VU	2
	Commercial	VC	15
Aircraft & Watercraft	-	AW	5
Bridge & Structure	-	BS	1
Building Block	-	B	52
Construction machine	-	CS	1
Texture	Architectural	TA	27
	Ground	TG	19
	Tile & Brick	TT	14
	Orthophoto	OR	-
	Miscellaneous	TM	1
Sea Surface	-	SE	2
Sky	-	SK	73
Miscellaneous	-	MS	1

4. TEXTURE MAPPING MOTION SETTING AND RENDERING

Texture mapping, motion setting and rendering are also important modules in the computer animation system.

Texture mapping refers to the application of colours and shading to computer images to mimic the look-and-feel of real life objects. CAS can extract texture information from photos of the existing site and allows users to vary the properties of objects such as reflection, refraction and opacity, say, give a metallic and chrome-like finish to vehicles.

Motion setting refers to the positioning and movement of the virtual camera with zoom-in and zoom-out capabilities through which the animation will be generated. The common practise in the Highways Department is that we create a path for the camera to follow.

Rendering is the step-by-step timeline instructions to produce the required animated frames. Considering the existing computer resources, the format of the computer animation films is standardised at 24 frames per second in the Highways Department.

The result of the above processes is a photo realistic three dimensional computer animation showing the proposed highway in relation to the existing environment through the viewpoint of drivers (drive-through), pedestrians/local residents (walk-through) or even birds (fly-through). The animation can be further enhanced by further editing of each of the animation frames or by adding special audio effects.

5. QUALITY REQUIREMENT

'Quality requirement' refers to the quality of the computer animation required, which in turn depends on the application of the animation envisaged by the users. As mentioned above, consultation with the public is one of the important applications of the CAS. While this application does not demand high positional accuracy, it is necessary to incorporate realistic texture and high resolution features, such as street furniture and trees, in the animation. In addition, it is necessary to produce animations from the perspective of the viewers, such as a drive-through animation from driver's point of view, a walk-through animation from pedestrian's point of view, and a pan-view from resident's point of view on the visual impact assessment.

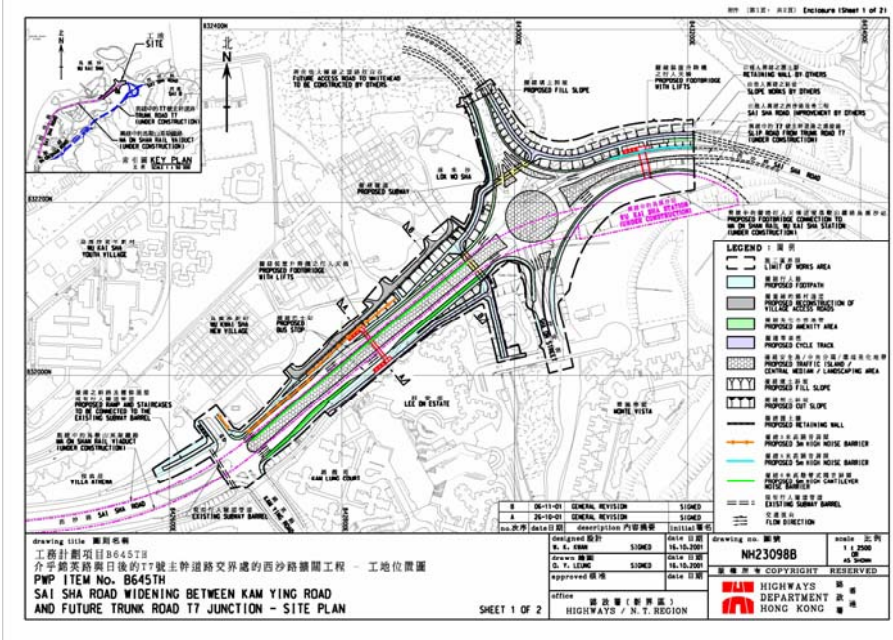
Apart from public consultation, professionals have made use of the computer animation for design purposes: route selection and inter-visibility study. For route selection, engineers are concerned about the land use, the connectivity of the proposed highway with the existing road network, the impacts to the environment, the amount of earthworks involved, and ultimately the minimisation of land resumption and reduction of the project cost. Issues such as texture quality and the positional accuracy of street furniture will be of less importance, and therefore it is acceptable to adopt a lower resolution. A fly-through animation can meet the general requirements of this kind of application. We use the digital terrain model textured with the appropriate orthophoto map as the background of the 3-dimensional animation and superimposed with a simplified alignment of the proposed road. This significantly reduces the complexity of the animation model and hence saves the computation time and production costs.

For inter-visibility study, users need to ensure that the line of sight of drivers and pedestrians meets the road safety standard. Such standard is stipulated in the Transport Planning and Design Manual. In the past, the minimum line of sight is measured manually on plans. With the use of the 3-dimensional animation, the detailed design of the proposed highway can be visualised through the system. Any street furniture such as lamp post, sign post, sign gantry or other obstructions can be easily identified. This kind of application requires high positional accuracy, but texture quality and other aesthetics details are of less concern to the engineers.

6. EXAMPLES OF APPLICATION OF CAS

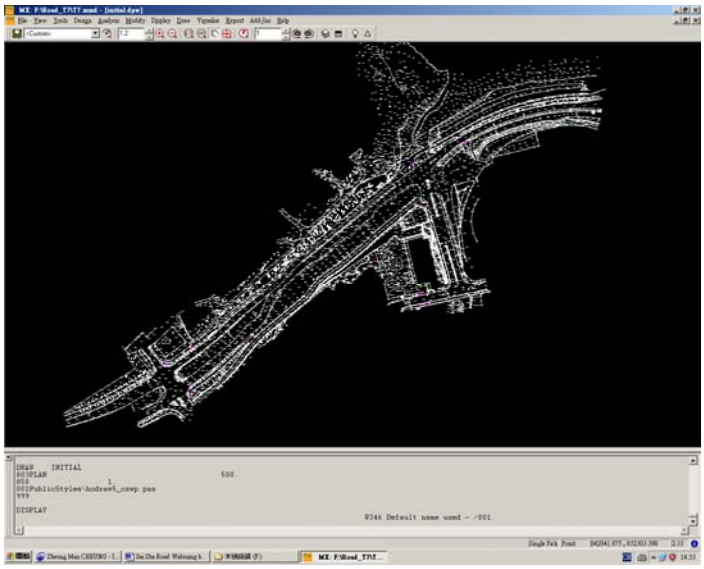
The Highways Department has produced over 50 animations for about 40 road projects with the CAS. Two examples of the application are illustrated in the following paragraphs.

Example 1: Sai Sha Road Widening between Kam Ying Road and Future Trunk Road T7 Junction

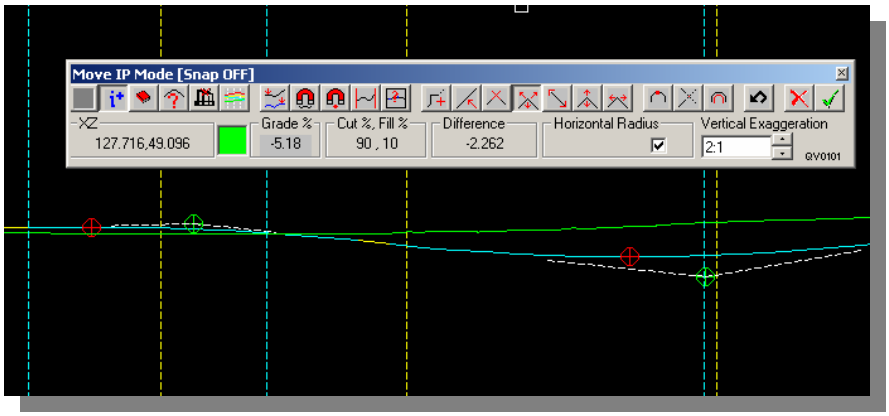


To cope with the completion of a major trunk road T7 and Ma On Shan Rail in 2004, the Highways Department commissioned in 2002 a project titled "Sai Sha Road Widening between Kam Ying Road and Future Trunk Road T7 Junction" to improve the neighbouring local road network. The project costed around HK$110 million and included the widening of a section of Sai Sha Road of about 650m to a dual two-lane carriageway as well as the construction of a roundabout. The project also involved the construction of embankments, retaining walls, cycle parks and erection of noise barriers along Sai Sha Road.
At that time, local residents raised concerns on the erection of noise barriers along the proposed road. Some of them were concerned about the aesthetics of the noise barriers, some were worried that the noise barriers would block the sightline from their village houses, and some questioned whether the noise barriers would provide an effective protection against traffic noise. To facilitate consultation with the public, the Highways Department prepared computer animation videos to illustrate the details of the proposed highway and the associated noise barriers in order to alleviate the worries of the local residents.

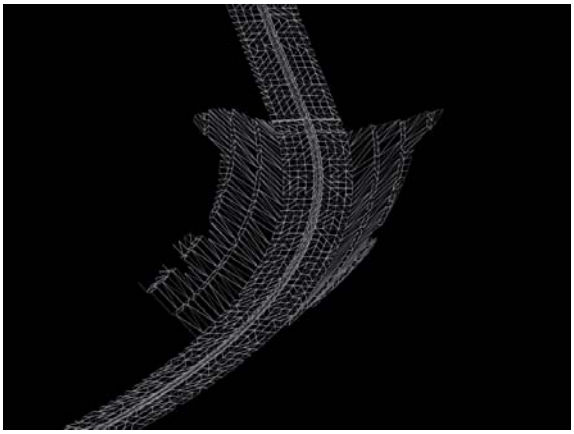
The following diagrams show the road alignment design, design road model and drivers' view by using MX Road and the computer animation system.



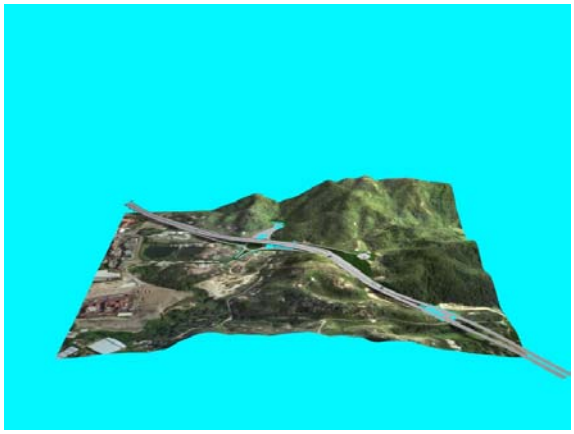
Initial Survey Model



Horizontal and Vertical Alignment Design in MX Road



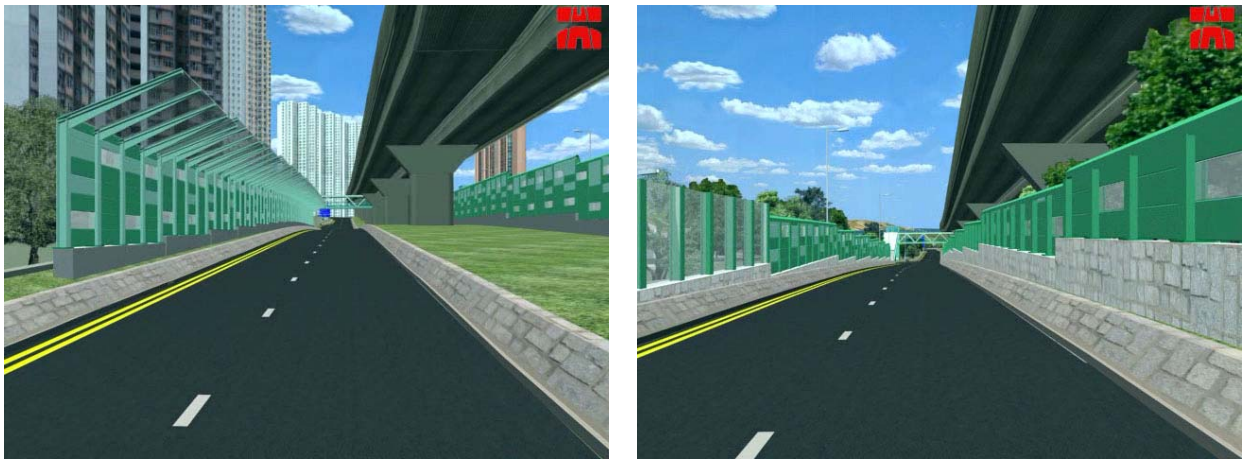
Road Design Model in MX Road



Model with orthophoto map

The following snapshots animate the views of driving through the proposed Sai Sha road:

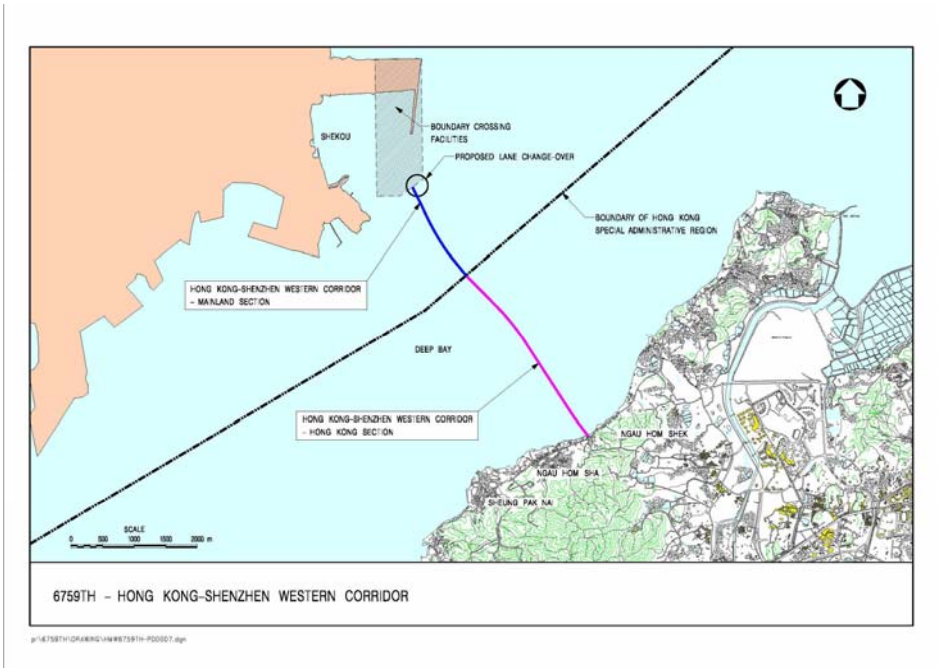
Views at the roundabout



Visual impact assessment on noise barriers

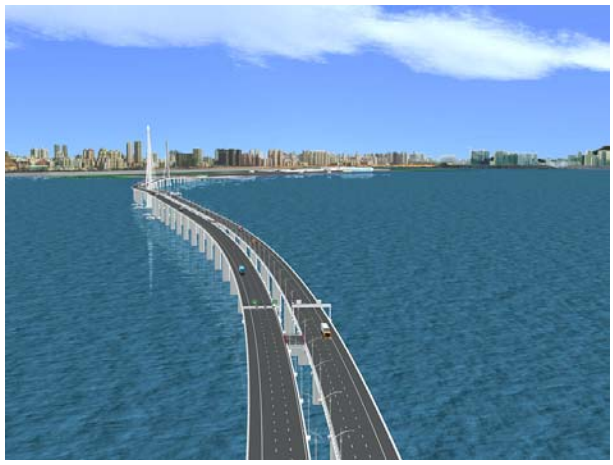
Visual impact assessment on footbridges

Example 2: Hong Kong – Shenzhen Western Corridor



Hong Kong-Shenzhen Western Corridor is a 5.5 kilometres long cable-stayed bridge. It begins at Shekou of Mainland, stretches across Deep Bay and lands at Ngau Hom Shek in the north-western part of Hong Kong.
The Hong Kong section of the bridge is a 3.5 kilometres long dual 3-lane carriageway and costs around $3.2 billion. Construction works was commenced in August 2003 and it is expected that the Corridor would be opened soon.

The following diagrams shows the snapshots of the fly-through animation on this project:

Overview of the project


Bird's view of the bridge


Bridge at night

The animation produced for this project is available in the Highways Department's website (http://www.hyd.gov.hk) under the section "Major Projects -> Major Works -> Hong Kong-Shenzhen Western Corridor".

7. EXPERIENCE LEARNED

Production of an engineering computer animation is like producing of a movie. Like a movie director, the controller of an animation project needs to design the storyboard and to plan and design every 3-dimensional animated scene in detail, so as to satisfy the requirements of the clients. While the Autodesk Viz or 3DS Max is a powerful tool for animation production, the operation of the system is not straight forward. Extensive on the job training has to be provided to the staff. In addition, data sources are always in different formats with different file structures. Hence we need to well organize the data from different sources and to convert the data into the required format when required.

Knowledge on quality and user requirement is vital to the success of a computer animation project. Creation of 3-dimensional objects with unnecessarily high resolution images/photos and over complicated model structure and faces would result in large file size and substantially lengthen the rendering processing time, or even cause the system failure. To reduce turnaround time, we need to make the best use of the computer equipment and software available to cope with their processing capacity. We sometimes pool a number of workstations so as to complete the assignments within the allowed time. In addition, we also need to cater for the processing power and connecting bandwidth of the viewers' computer machines.

8. CONCLUSION

Computer Animation System is a tool not only adeptly serves the engineers in the assessment of the road design work but also enabling the public to visualize the highways design. The Highways Department has used the software successfully in over 40 projects and more than 50 computer animation videos have been produced. It is envisaged that CAS will become a key tool in every road project in future.

ACKNOWLEDGEMENT

The author would like to acknowledge the Director of Highways for his support and approval for presenting the paper.

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