Micro-Simulation Function to Display Textual Data in Virtual Reality

Wael A. Abdelhameed

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Abstract

Virtual reality creates an effective communication platform with a high degree of perception and exploration, increasing the benefits of VR applied functions. This research paper reports a virtual reality function of using the micro-simulation editor-player with XML file in the virtual reality environment. The details of the function are presented. The function aiming at combining visual and textual data in VR model visualisation, was developed by the researcher, and was included in the micro-simulation plug-in of a virtual reality program, VR Studio version 6, previously known as UC-Win/Road, by the program developers. The research paper discusses the computer simulation techniques and uses in virtual reality in general. The research paper proceeds to introduce a case study of construction process visualization in the virtual reality environment, in which the newly developed function is utilized to simultaneously visualise data reports related to the stages of VR model visualisation. The concluding remarks accentuate this micro-simulation function with its potential uses in different fields.

Keywords: Micro-Simulation, XML, Virtual Reality, Construction Process Visualisation

1. INTRODUCTION

Micro-simulation is a category of computerized micro-analytic tools that perform highly detailed analysis of activities such as traffic and transport planning, monument areas preservation and restoration, or damage spreading earthquake/hurricane through a certain area. Micro-simulation is often used to evaluate the effects of proposed interventions before they are implemented in the real world. Micro-simulation differs from types of computer modelling in that it looks at the interaction of individual units such as vehicles, pedestrians or structural elements – as applied by this research.

The concern had initially brought to macro-simulation models by the late 1960s and early 1970s, where macro-simulations of feedback processes in industries and global populations were applied through computing technology (Luk, 2006). These macro-simulation models used differential equations to predict population distributions as holistic functions of other systematic factors such as urban traffic, migration, and disease transmission. The feedback conclusions discredited the field by demonstrating the extent to which results of the models are highly sensitive to the specific quantitative assumptions. Micro-simulation models therefore were brought to concern as a result of increasing skepticism about employing computational tools to make predictions about macro-level behavior (Leduc, 2008).

In micro-simulation models, forecasts and policy study effects are made by modelling aggregate changes in state of individual-level entities rather than changes in distribution at the population level. Although micro-simulation models do not permit individuals to interact, these models have been widely recognised since the middle of 1970s (Merz, 1994).

2. SIMULATION TECHNIQUES

Simulation techniques can be broadly classified into the following four types:

- Analytical: this technique relates directly to the attributes of different units/models in simulation modelling that govern these unit/model behaviours. For example, the attributes in traffic flow theory can be a set of equations of driver behaviour such as gap acceptance, lane changing, or car following. The combination of analytical models can constitute a more complex analytical tool. Individual sets of analytical equations can also act as sub-models in other simulation techniques.
- Microscopic: the movement of a unit/model in a microscopic simulation can be set up through a certain position/area over certain time at a small time increment of a fraction of a second. For example, a detailed simulation of vehicle-road interaction under the influence of a control measure is therefore possible. By using more computational resources, this technique is useful for a wide range of applications.

Random/stochastic number generators are involved so that it is difficult to optimise model parameters, for example signal settings in traffic. In a different application path, a detailed construction process with a proposed schedule can be visually represented through micro-simulation that is controlled by XML file. Modifications in the proposed schedule under the influence of any emergent requirements could be easily applied in the XML file and then be visualized (Abdelhameed, 2012).

- Macroscopic: units/models in a macroscopic simulation are no longer simulated individually. Unit movements/behaviours are often simulated as packets or bunches in an area with a time step of one or several seconds. An analytical model can be used to govern the movement of a unit/model. A macroscopic simulation is deterministic by nature and is useful for network design and optimisation.
- Hybrid: this technique is sometimes known as mesoscopic simulation. It combines a detailed microscopic simulation of some key components of a unit/model (e.g. intersection operations) with analytical models (e.g. speed flow relationships for traffic assignment). The unit/model in this technique can represent more than one purpose/assignment to be studied/visualised.

3. MICRO-SIMULATION APPLICATIONS

The micro-simulation player is a feature in the VR environment to play animations of various types of simulations, which are expressed through the movement of 3D models. The aim of micro-simulation player is to present results to users through the installation of the plug-in for the reproduction of simulation results from other applications, which are defined in the XML file format. The micro-simulation player enables the VR program to be easily linked with all traffic micro simulations (cars and trains).

At the beginning use of micro-simulation, it was broadly employed in the engineering discipline for traffic and road studies. Micro-simulation manifests its ability in modelling road vehicles including signal coordination, one-way systems, different types of intersection control, signal priority and driver information systems. In addition, trams, pedestrians and cyclists can also be simulated. The widest application of micro-simulations is to visually represent predicted traffic behaviour through 3D animation.

A record containing a unique identifier and a set of associated attributes control each unit within the model during simulation, e.g. a list of vehicles with known origins, destinations and operational characteristics. Each unit is treated as an autonomous entity and the interaction of the units is allowed vary depending on stochastic/randomized parameters. These parameters are intended to represent the real or proposed preferences and tendencies. For example, in a traffic model some drivers are cautious and have a large gap

before turning, while others are aggressive and feel comfortable with small gaps.

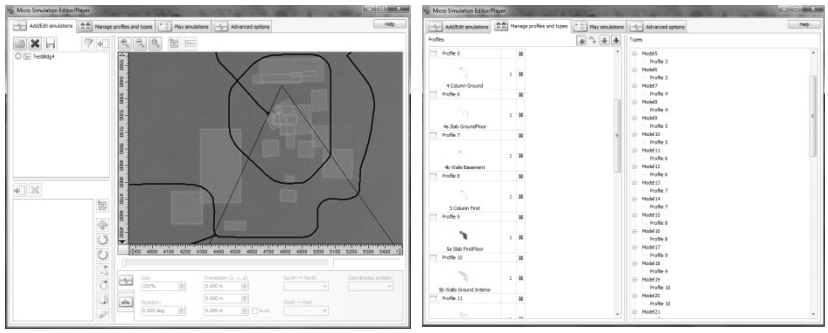
In recent years, the synergy between information technologies and traffic engineering has enabled a new generation of micro-simulation models now available for road and transport managers to analyse complex traffic operations. Further advances are being made in using micro-simulation with the merging of micro-simulation model data with cinematic quality 3D animation and with virtual reality. Stochastic/randomized parameters employed within the model are also being shifted to controlled parameters by using XML file.

3.1. Main Specifications

The main specifications of micro-simulation can be summarized as follows,

- 3D animation function: Animation of 3D models saved in the publicly available XML file format. Various types of 3D model animations can be created based on the model's location information. It enables to run several data at the same time.
- Control of visual effects for objects: Movement commands, state of traffic lights, transparency, MD3 character animation, Figure 1.
- Control of existing objects: Static objects such as traffic lights can be controlled, Figure 1.
- Control of visual options: Time, weather, light, etc.
- Optimal integration with the functions of VR program: Traffic, script, camera mode, Figure 2.

► Figure 1, Images of micro-simulation function Windows, taken from the research application of construction visualisation.



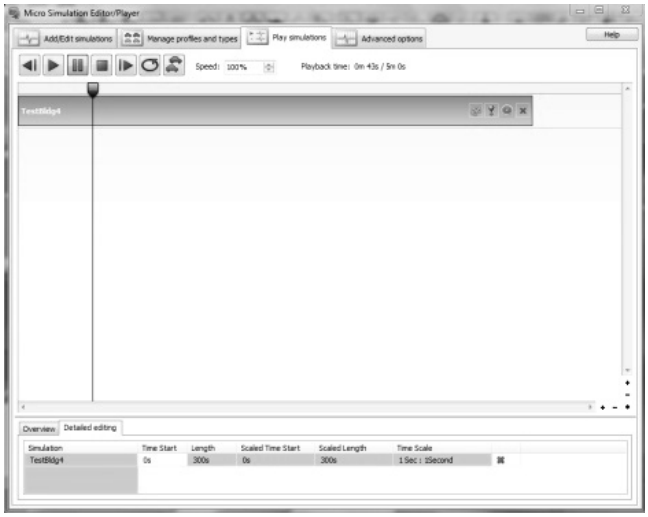
a- Preview Window

b- Model Profile Editor Window

3.2. Use in the construction Process

The micro-simulation player facilitates the change of model-parts order in the visualisation process. The possible modifications of the construction process can be identified based on the structural/constructional logic, and accordingly be applied in the visualisation process. At any modification of the construction process, units presenting the structural elements and the

construction reports, therefore, can be easily modified in the XML file through their parameters.



◀ Figure 2, Micro-Simulation Editor-Player Window.

Using the XML file with the micro-simulation player enables easily applying modifications. The parameters of units can be changed to reform the VR model and its associated reports based on any scenario of the construction process. A computer programming background, but not advanced, is needed to change the unit parameters.

4. XML FILE WITHIN MICRO-SIMULATION

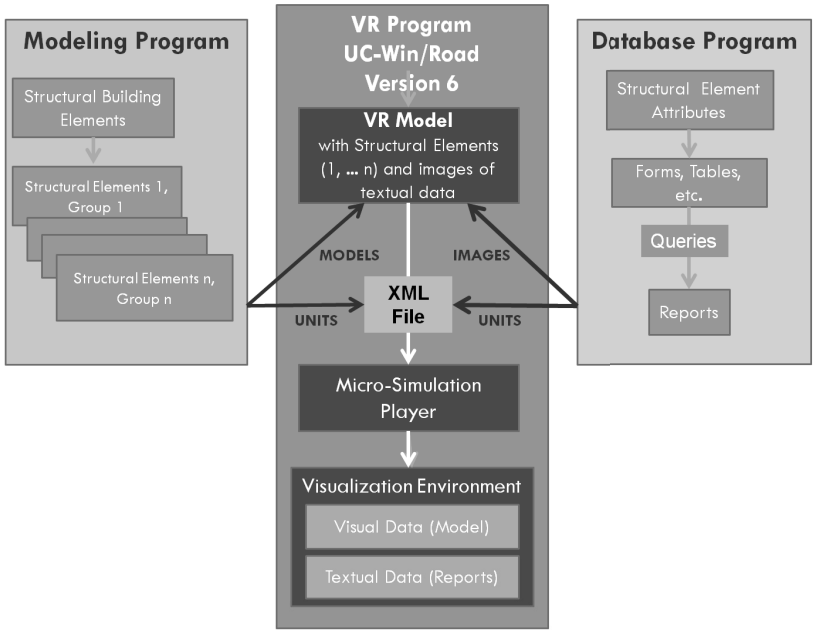
The technique of micro-simulation, or simulating the movement of individual units, has long been used for traffic analysis and transport solution identification. These applications are often complex, congested situations that are normally beyond the domain of analysis using conventional analytical or macroscopic modelling procedures. However, another technique employing less analysis and benefiting from real-time potential of VR can be applied. A VR application through which micro-simulation and XML file are employed in project management scheduling was introduced to visualise the construction process (Abdelhameed, 2012). The potentials of VR model in visualization and communication were the focus of this foregoing research application, rather than the process of using micro-simulation and XML file.

VR Studio version 6, the VR Program of Forum8 Company, adapted the new VR function for viewing the textual data. Using the VR technique of micro-simulation and XML file in visualizing the construction process will be the focus of my research, which proceeds to present details of this new VR function.

4.1. Research Technique

Through the technique presented by this research, different computer programs are employed to construct the VR model. The following part describes steps of the modelling process. The model consists of parts which can be created by a computer modelling program e.g. 3ds max. These model parts are uploaded in the VR program as separated model parts with their position parameters according to the terrain area used and presented in the VR program. The data reports made by a database program e.g. MS Access or a project management program e.g. Primavera, are also uploaded in the VR program as images. The XML file role is to control visualisation of models and reports through their time parameters, which are controlled and processed by the time function of micro-simulation player. Figure 3 shows a diagram of the process of using the structural groups and the construction reports in the XML file within the micro-simulation player.

Although a computer function can be developed to read the textual data and present them as text not images, this method was not adapted by the researcher whereas the goal is to build up a connection between different computer programs, rather to develop a function whose output can be replaced by existed functions of other commercial programs. Another reason is the time and labor required to develop such a function.



► Figure 3, A diagram shows adding textual data to the VR model for construction visualisation

4.2. XML File for the Construction Process

In this part, the research presents the algorithmic process of constructing the XML file. The movement and status of all 3D models in a scene are defined in the XML format for saving animation data. 3D meshes of the models are not stored in the XML file, but a link to the associated 3D model parts is. The textual data, the newly applied by this research, are dealt with in the XML file as units. Additionally, it is possible to set weather, time and other visual effects.

A playlist can be created to play more than one XML file at the same time. The playlist has a time offset for each item and can be used simultaneously for multiple datasets. Moving objects are created in place and move based on a linear interpolation of location coordinates. During simulation, traffic flow is set to on. In addition, long distance simulations over short time periods and high-speed playback of low-speed movements are also available. However, the technique adapted by this research is less complex and applies only one XML file with a database set of model parts.

In the algorithms of XML file, the units are the structural elements and data of the construction process. The proposed scheme/scenario can be modified through changing the unit attributes enabling laypeople e.g. politicians and the general public to effectively compare between the impacts of different schemes/scenarios.

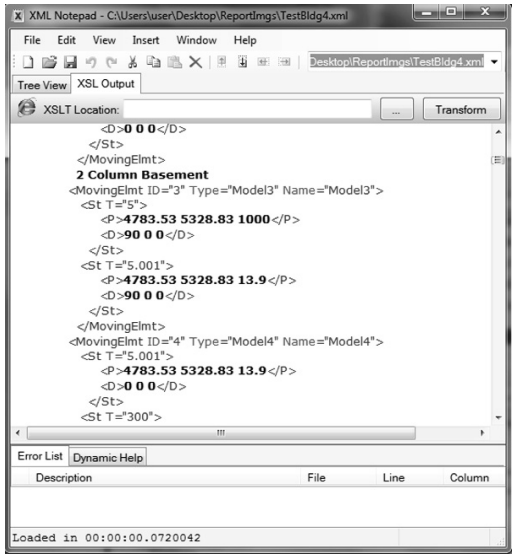
4.2.1. Structural Elements

The structural elements are grouped according to the construction process proposed in the project schedule. The XML file includes the groups of structural elements with possible alternatives as units of the VR model in order to facilitate the visualization of any construction process modification. Attributes and parameters of these units are specified in the XML file in terms of location and time through which these units are visualised in the VR model, Figure 4.

4.2.2. Construction Process Reports

The contribution of the VR function adapted by the VR Studio version 6 is to display textual information simultaneously with visualisation of the construction stages. In the VR function, the textual information can be construction process reports or other data required by users. These reports are visually displayed in a separate window of the VR Program. Each report is displayed during the visualisation stage of the related structural group/unit, Figure 5.

► Figure 4, A part of the XML file used in the application of construction process visualisation



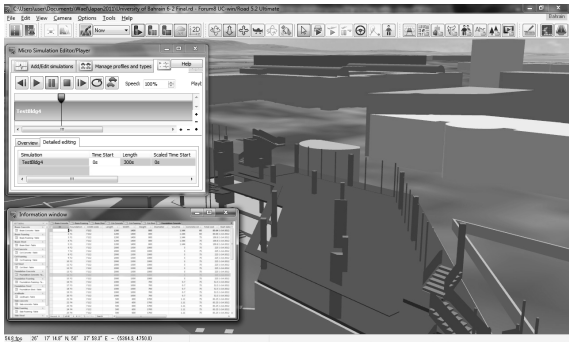
Attributes and parameters of reports are specified in terms of the time used in the visulisation process. The reports are processed in the VR program and its micro-simulation plug-in as images.

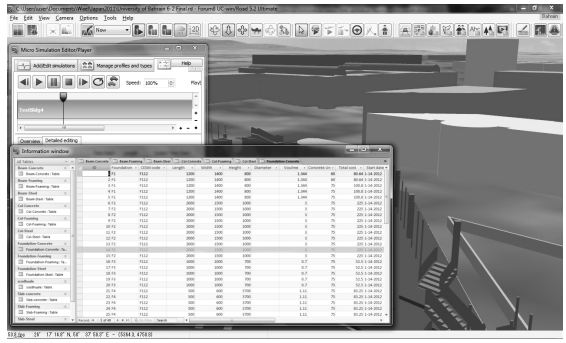
5. AN APPLICATION OF THE NEW VR FUNCTION

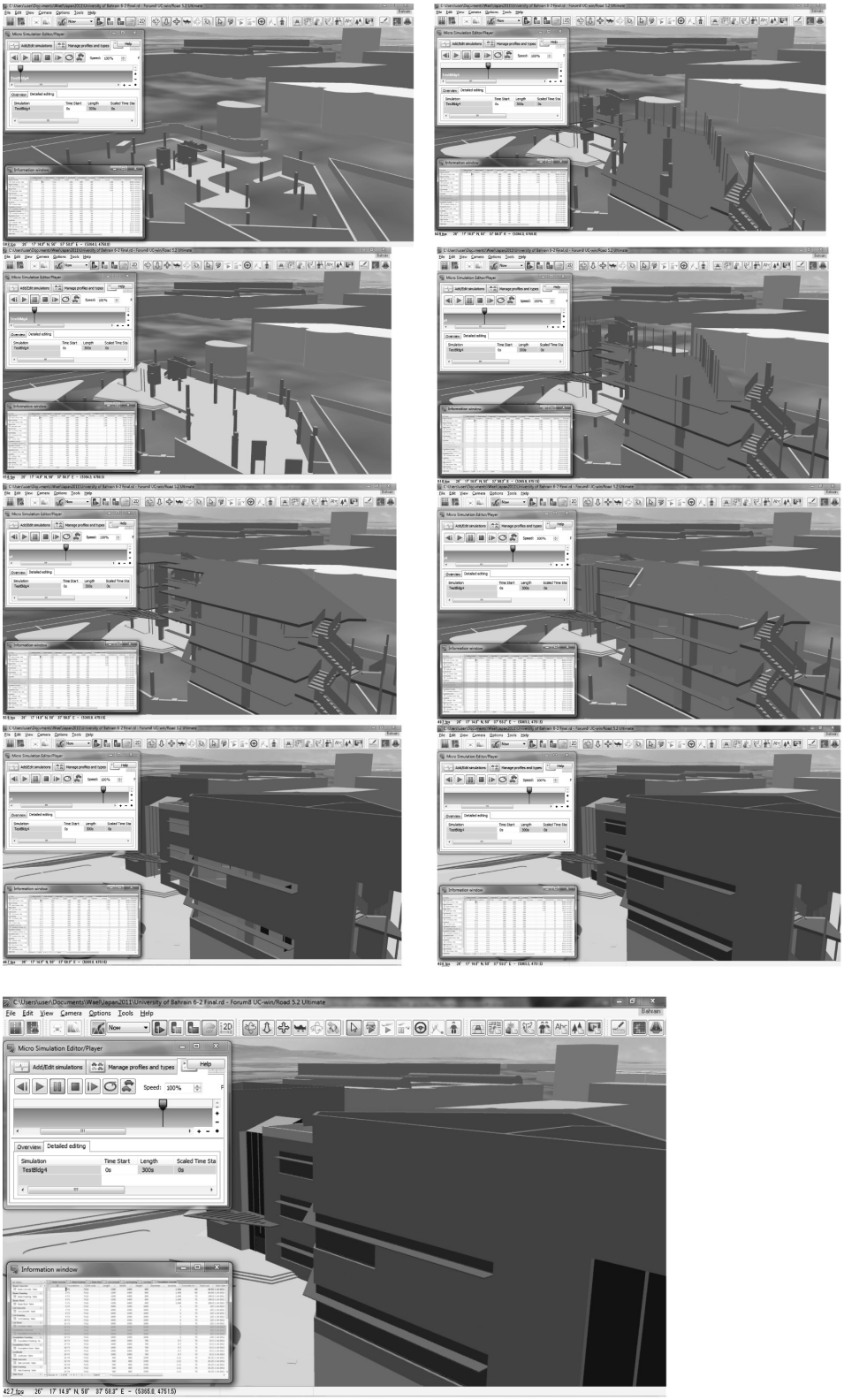
A new administration building of the University of Bahrain is used to manifest advantages of the new VR function in construction visualization, Figure 6. This application of the VR function concentrates on using the displayed data on construction monitoring.

In case of any proposed change in the construction process, updated images of new reports are uploaded in the VR program, and attributes of the report images are modified in the XML file based on the construction modification proposed.

▼ Figure 5, Two screenshots of the VR Program, showing the window of displayed data which can be controlled by the user during visualisation







◄ Figure 6, Images from one camera position showing some construction stages with their related data

5.1. Construction Monitoring

Construction monitoring aims to providing a brief summary of the construction activities, identifying construction stages, any problem areas, unauthorized impacts, and corrective actions. Construction monitoring specifies if changes are proposed to the permitted impacts or site plan. Detailed information is to be provided in the main report. As part of construction monitoring, photographs are used in the reports to visually describe different stages. Based on this interpretation, the data displayed should not be fixed in order to satisfy and conform any model, project, situation, stage, or schema/modification.

The construction process of the new administration building has not been started. Therefore, the research application can help in displaying the proposal plan for the laypeople and decision makers.

5.2. Displayed Data

Using the reports created by any project management program is one method. Another method however is proposed by the research, through using certain data made by a database program. The flexibility of this method, which can fulfill any project or scenario is achieved by displaying construction data associated with other data related to the project and required by the users.

What data should be displayed in the research application used by the Engineering Office of the University of Bahrain? A proposal was sent to a number of CEOs and project engineers, not to conduct a survey as this is not the research concern, but to have their inputs to be used in the university project, Figure 7. According to the point of view of the researcher, the displayed data have to be flexible for different uses, as discussed earlier, consequently different images from various programs can be used.

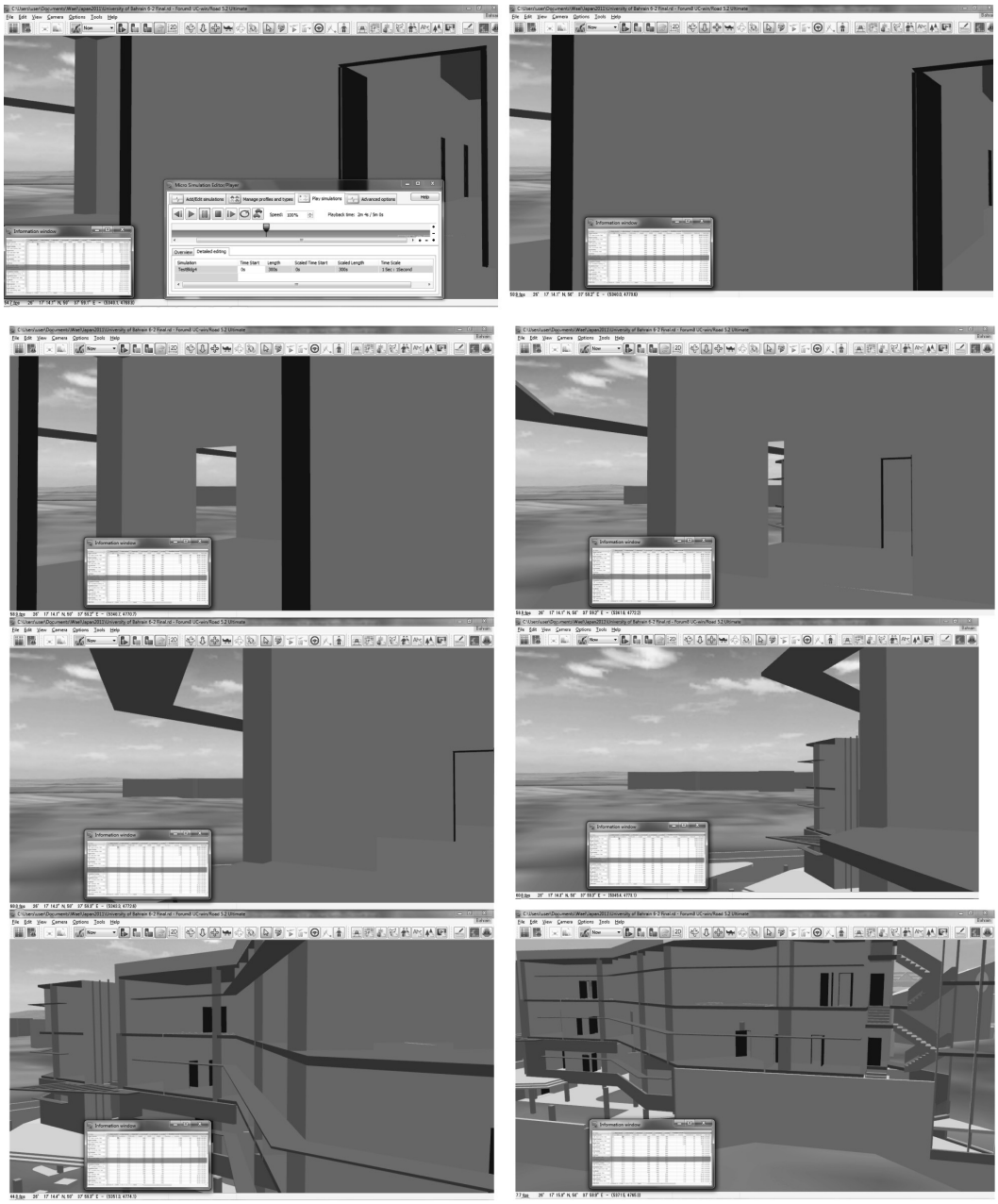
► Figure 7, the proposal/data used in the VR model of the new administration building

ID	Task NO according to British or American Standards	Task	Schedule data				Structure Data				Monitoring Data					
			Duration	Start Date	End Date	Status	Area	Volume	Concrete Amount	Steel Amount	Constructional Method	Surface Area	Framing Way	Framing Duration Time	Casting Way	Casting Duration Time
		Site Preparation				Completed										
		Excavation				Completed										
		Foundation				Completed										
		Ground Floor Columns				Completed										
		Masonary 1				Completed										
		Masonary 2				Ongoing										
		Ground Floor Slab				Ongoing										

6. SUMMARY AND DISCUSSION

The developed VR function was introduced and discussed. Employing this function in a VR program, the UC-Win/Road Program, the research presented an application of the construction process of a new building in order to highlight contributions and advantages that can be provided to the users. Other benefits can be achieved in the construction visualisation through navigating the model at any construction stage, Figure 8.

▼ Figure 8, Screenshots of building interiors and exteriors during one displayed data window, showing the VR navigation through the model while micro-simulation pause.



The new function has potentials in different disciplines for example traffic and transport simulation. Certain displayed data of vehicles, traffic lights, road intersections, or road traffic densities can have such importance in VR visualisation. These displayed data enables the VR model to be more informative and effective in terms of different uses.

There are complex traffic processes and traffic flow theories, such as adaptive signal control algorithms, incident management strategies, active bus/tram priority and driver information systems, which are often unable to accurately predict the impacts in terms of delay, queue length, travel times, fuel consumption and pollutant emissions. A real-time interactive function can be added to the displayed data function which introduces an effective tool for prediction and communication.

Other areas in traffic and transport simulations such as the algorithms of car-following and lane changing simulations, and the comparison of macroscopic and microscopic simulations can utilize data displayed for different functions within the simulation process. Meaningful results can be interactively shown especially in the lane changing behaviour in congested conditions, which enable idea emerging and solution evaluation.

A non-proprietary XML file schema can enable the exchange of simulation results between software programs. Using the micro-simulation player, traffic, pedestrian and other micro-simulation data from leading micro-simulation softwares can be imported into the VR environment for 3D Visual Interactive Simulation. Adding textual data interactively displayed in the 3D Visual Simulation enriches the visualisation process.

Of other disciplines that can employ micro-simulation with textual data through XML, urban designing and urban planning have areas such as rural road operations and building height schemes that can be accurately evaluated and effectively displayed through such simulations.

In general, simulation applications have a wide range in engineering, architecture and urban fields. Using textual data inside these simulations empowers visualisation functions and results with the associated information. Achieving real-time interaction in the displayed data function through micro-simulation of the visualisation process will effectively contribute more in the communications of laypeople, stakeholders and decision makers.

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