

VEHICLE DYNAMICS SIMULATION PART 2: PRESENTING THE SIMULATED VEHICLE DYNAMICS IN VIRTUAL 3D ENVIRONMENT

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1. Introduction

Presenting the results of a vehicle dynamics simulation requires a means to compare them to behaviour of real vehicles. One way of achieving this is presenting the results as animation in a virtual 3D environment. Since the vehicles and other objects, involved in the simulation, have to be shown realistically, we have started to build up an integral library of low polygon-count 3D vehicle and road object models. The first goal of the presented work was to develop a way to quickly and cheaply model large quantities of 3D vehicle models.

Two starting points were set:

- vehicle models have to be modelled upon real vehicles and, once finished, have to be recognisable from every point of view in virtual 3D space,
- number of vertices (and thus number of polygons) has to be kept as low as possible, to enable display of animations on the widest possible range of hardware.

During modelling, special care was taken to achieve balance between these two contradicting requirements.

The primary use of a library of 3D geometrical models is in presenting vehicle dynamics [Ciglarič]. This includes visualisation of traffic accidents and driving dynamics for various reports and analyses, use in driving simulators, etc. The results can be presented as animations as well as sets of still images. An example image of vehicle models on a virtual driving surface is shown in Figure 1.



Figure 1. Vehicle models on a virtual driving surface

The secondary use of 3D geometrical models of vehicles is in determining visibility from different positions as well as traces and damage on vehicles and other objects during minor collisions. This can also be applied in traffic accident investigation [Brösdorf]. An example set of images from a driving simulator application is shown in Figure 2.

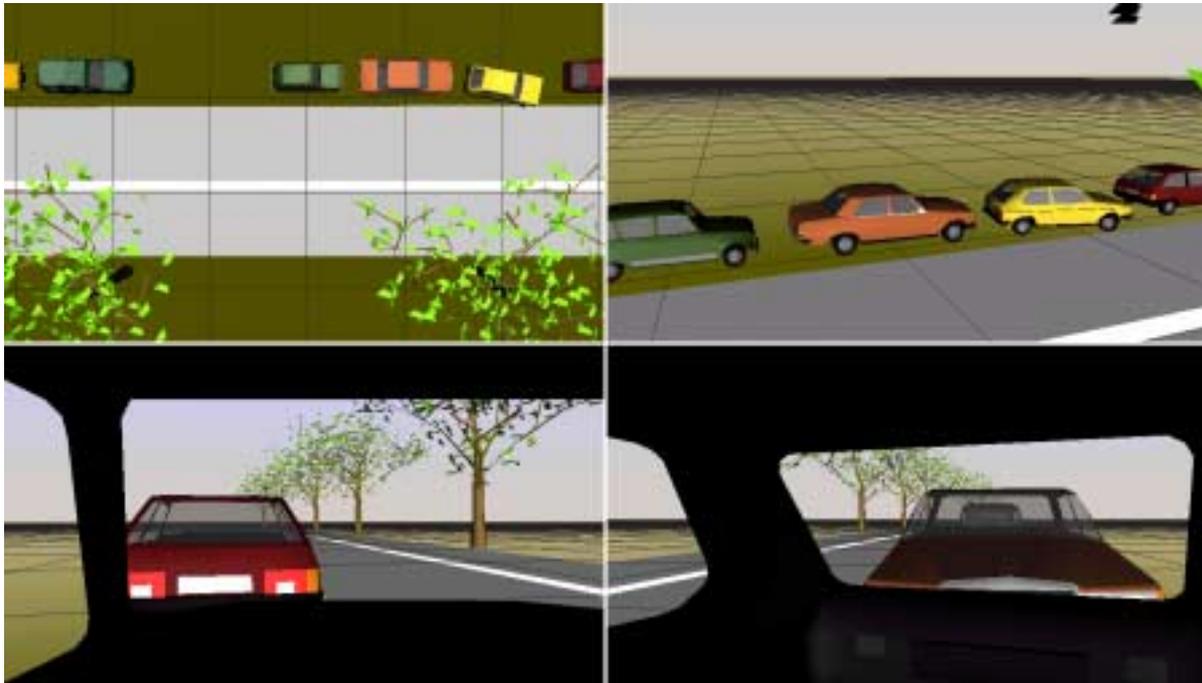


Figure 2. Different views from a driving simulator application

2. Preparing the 3D virtual environment

2.1 Generating the 3D geometrical models

To make the 3D geometrical models suit the requirements of the animation engine [Ambrož], a process of generating 3D VRML2 geometrical models from series of photographs has been devised. The entire process consists of six main steps:

1. *Acquiring a set of digital photographs* of the object to be modelled. This can either be done with a standard film camera or a digital camera. The benefit of using a digital camera is better and more consistent geometrical accuracy of photographs and the absence of having to digitise the photographs, while scanning negative films can yield higher image resolution and lower initial cost for equipment.
2. *Editing and converting the photographs* into a format suitable for photomodelling. In this step the digital photographs are edited (colour equalisation, sharpening etc.) and converted to a format, suitable for input into the photomodelling software.
3. *Photomodelling*. By using photomodelling software (products such as AEA Technology Geometra or EOS Systems PhotoModeler), in this step the data from the photographs is processed and used to generate 3D geometry. This step is the central part of the model generating process and represents around 70 % of the time used for creating a model. Since most ordinary road vehicles are symmetrical regarding the vertical plane along the vehicle length, we usually model only one longitudinal half of a vehicle to conserve time and reduce the required number of photographs. As a result of this step we get a raw model of one half of a vehicle (Figure 3). The "raw model" in this case refers to a model that only contains basic geometry and to which the information (such as scale, orientation and colour) has to be added during the further phases of the model generating process to make the model suitable for use with the animation engine.

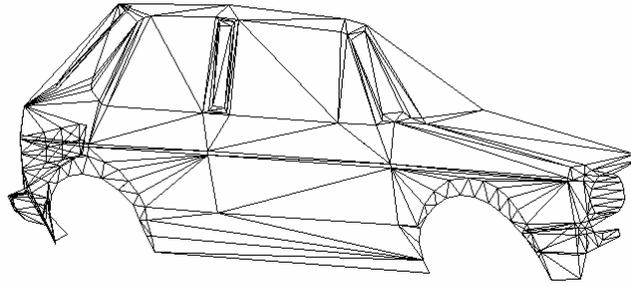


Figure 3. Raw model of a half of a vehicle

4. *Raw model editing.* First, the raw model of a half of a vehicle has to be mirrored to get a raw model of the entire vehicle (Figure 4). Additional features that cannot be photomodelled (vehicle bottom, wheel opening inner walls, hidden geometry of commercial vehicles etc.) are added to the raw model afterwards (Figure 5). This is also the step where we can correct any possible errors (such as missing or misplaced points) that may have been done during photomodelling.

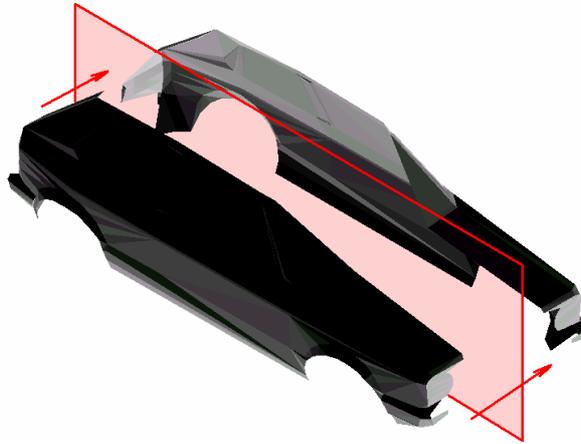


Figure 4. Raw vehicle model after mirroring

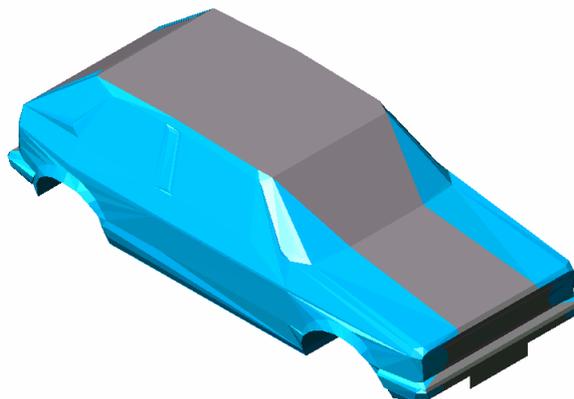


Figure 5. Vehicle model with added surfaces that weren't photomodelled

5. *Scaling and conversion.* The raw model has to be properly scaled and coloured to reflect the size and the colour of the real vehicle. Special care is taken when assigning colours to groups of surfaces to make the vehicle model suit the colour changing mechanism of the animation core. Properly scaled and coloured model (Figure 6) is then converted into VRML2 format and edited (this includes adding

the "Driver's view" viewpoint and metacommands used by the VRMLPath programme interface). After this step the model is ready to be used in animation.

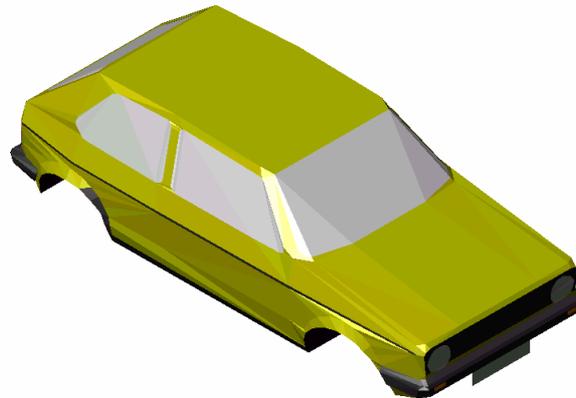


Figure 6. Scaled and coloured 3D vehicle model

2.2 The animation engine

After considering several options of creating animations from simulation output data, we have chosen VRML2 as the platform to build on. We have developed a universal animation core in VRML2, which is the base of the animation engine (Figure 7).

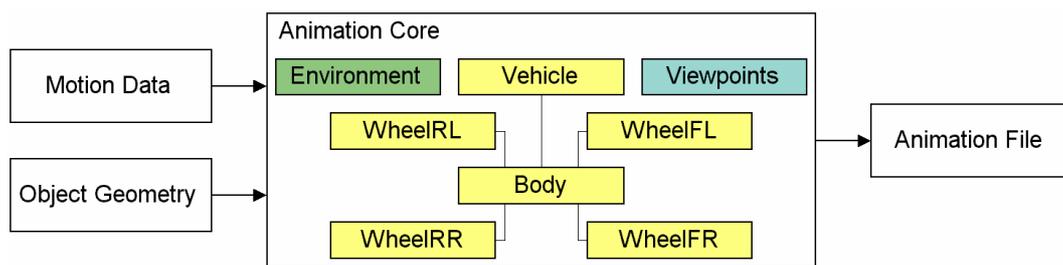


Figure 7. Animation core (example for a vehicle with four wheels)

To control the behaviour of the objects in the virtual 3D environment we have developed a modular application, which is interfaced with the animation core via VRML Automation Interface. This way we can add functionality to the application by adding modules for specific tasks. To date we have started to develop the following modules:

- module for creating animations from the results computed by the mathematical model of vehicle dynamics,
- module for connecting the animation engine and the mathematical model of vehicle dynamics to an existing vehicle database,
- module for comparing simulated vehicle movement to a video of a real vehicle movement,
- module for writing animations into AVI videos,
- module for on-line driving simulation (using real-time input from control device connected to the computer).

3.The VRMLPath programme interface

The first four modules are combined into a Win32 application called VRMLPath, which acts as the programme interface between the mathematical model of vehicle dynamics and the animation in virtual 3D environment. VRMLPath enables the user to:

- select a vehicle model from the list,
- display the vehicle model in the built-in preview window,

- view and/or edit the file with the vehicle model in an ASCII editor,
- select a pre-computed motion curve (or, if the required external modules are available, compute a new one using the current version of the mathematical model),
- add a 3D model of a driving surface (as an external VRML2 file, acquired, for example, from a GIS measurement),
- add custom objects (vertical signalisation, plants, buildings, auxiliary objects etc.) to the animation and manage their position and appearance,
- prepare the animation and display it in the animation window, which provides controls to start/stop the animation and set its speed, and allows the user to navigate the virtual environment,
- write the virtual 3D scene into a file that can, in general, be transferred to any system and viewed with any VRML2 browser,
- load a digital video file and play it in sync with animation for a visual comparison,
- save the animation into an AVI video file for use in presentations.

The user interface is designed to enable the user to accomplish all these tasks quickly and is ready to provide consistency throughout the application, even with future expansions to the VRMLPath. Each step of the animation creation process is represented by a tab in the VRMLPath main window. This makes the user interface clear and any changes to the input data easy.

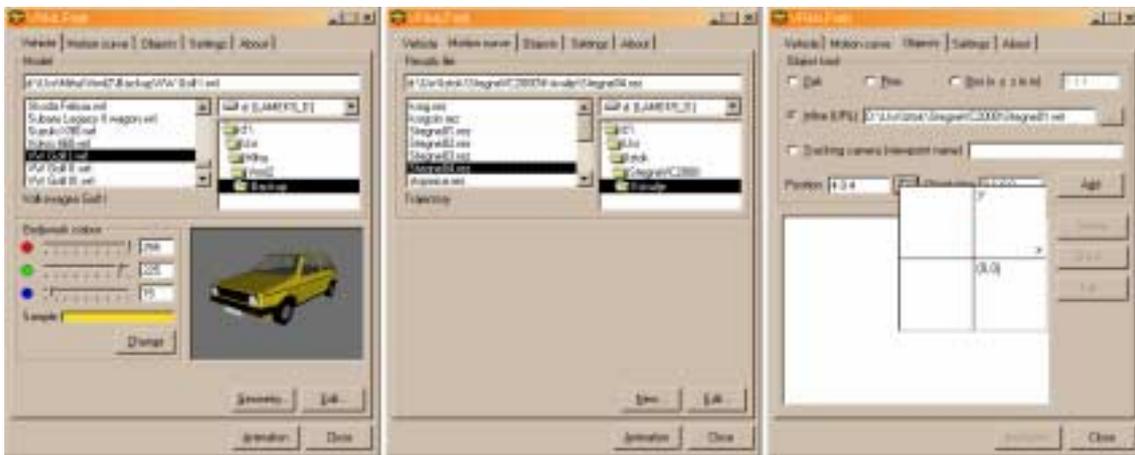


Figure 8. VRMLPath user interface

VRMLPath is connected to an existing database of vehicle data. This connection is used to automatically retrieve the relevant data about the vehicle upon selection of its model. The geometrical data is presented graphically in its own window that enables editing of data.

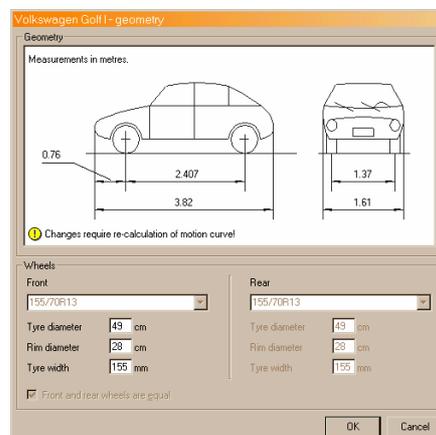


Figure 9. VRMLPath data window

One possible way of verifying the results of vehicle dynamics simulation is visual comparison of real vehicle motion and animation, based on simulation results. This enables qualitative analysis of the vehicle motion and can, together with other measured data, be used in testing the mathematical model. For this purpose we have developed a module that enables simultaneous display of digital video and animation in virtual 3D environment. The module is integrated into the VRMLPath application and enables easy start time synchronisation between the video and the animation and synchronous playback of the two.

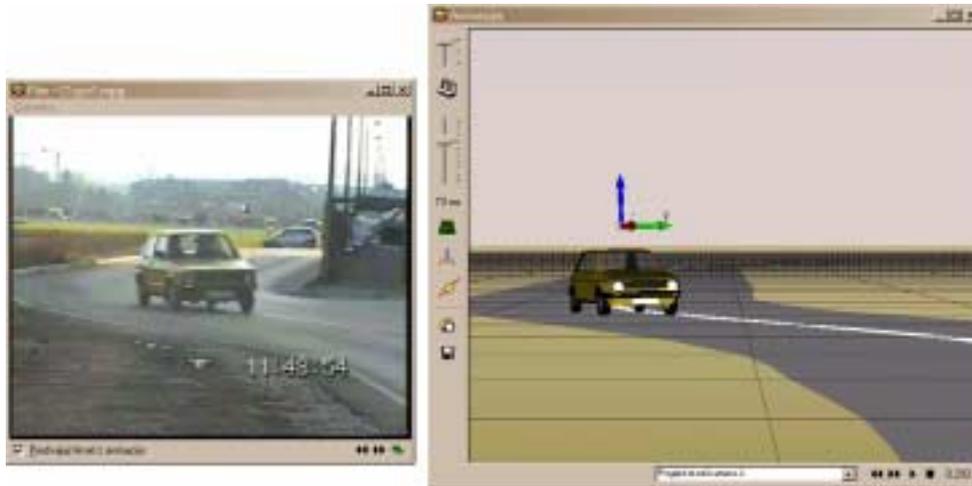


Figure 10. Synchronous playback of video and animation within VRMLPath

4. Conclusions

The current state of work, presented in this paper, enables quick and easy testing of mathematical algorithms and input data used by the mathematical model of vehicle dynamics. Procedures described enable us to quickly and cheaply produce large quantities of 3D vehicle models. The possibility of synchronous playback of animation and video enables the user to compare the model to the real vehicle. The ultimate long-term goal is to develop the current solution into a self-contained application for driving dynamics simulation, supported by an expanding library of 3D vehicle models.

The interactive driving simulation module, which is currently under intensive development, will broaden the field of use of the animation engine and its other modules towards interactive vehicle simulators. Along with the development of the mathematical model, future versions of VRMLPath will be developed to include modules to display animations of human body and its interaction with the vehicle and the driving surface.

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