Chapter 15
Building Virtual Driving Environments From Computer-Made Projects

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ABSTRACT

The virtual environments used in scientific driving simulation experiments require extensive 3D models of road landscapes, correctly modeled and similar to those found in the real world. The modeling task of these environments, addressing the terrain definition and the specific characteristics required by the target applications, may result in a complex and time-consuming process. This chapter presents a procedural method to model large terrain definitions and adjust the roadside landscape to produce well-constructed road environments. The proposed procedural method allows merging an externally modeled road into a terrain definition, providing an integrated generation of driving environments. The road and terrain models are optimized to interactive visualization in real time, by applying most state-of-art techniques like the level of detail selection and spatial hierarchization. The proposed method allows modeling large road environments, with the realism and quality required to perform experimental studies in driving simulators.

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INTRODUCTION

Procedural modeling of realistic driving environments is a rich research area that is usually addressed to the generation of 3D models, not only for entertainment but also for scientific applications, such as driving simulation. Driving simulators are usually considered as a very important scientific tool to conduct immersive experimental studies in different areas, like psychology, ergonomics, and roadways engineering. Experimental work in driving simulators requires a terrain and a road network definitions, both realistically modeled and prepared to real time visualization. The two models must match perfectly with each other, imposing that they be created together or within strongly interconnected tasks (Campos, Leitão, & Coelho, 2015a).

The large extensions of the environments and the detailed requirements imposed for each experimental work makes the manual design by specialists impracticable. Depending on the specific requirements of each experimental work, the use of previous created terrains or the use of models acquired from dedicated repositories may not be suitable and cannot provide the detail needed to generate the desired driving models according to the road network provided. Also, the use of data sources of real terrains, doesn't allow the freedom to impose particular terrain relief scenarios, such as ridge line at a specific point of the landscape, or even modify the mountains distribution in the specific terrain area. Large terrain definition, correctly modeled, corresponding to specific terrain areas, can be procedurally generated, significantly decreasing the preparation time of complete road environments that meet all the required specifications of each experimental work.

This paper presents an approach to generate driving environments, integrating several independent processes that can be applied sequentially to produce complete driving environments. The proposed integrated method to produce complete driving environments tries to mimic the three working phases that occur in the real world construction of road environments. First, the nature creates a terrain. Then, knowing the available terrain, civil engineers design a road that follows and fits the selected areas of the terrain. At last, when physically implementing the road, several adjustments are performed to the terrain, not only under the constructed road but also on its sides.

This paper is organized as follows: next section presents the state of art in the generation of virtual road environments, focusing the relevant related work. Following that, in section *Virtual Road Environments*, the proposed method is described and each included module is explained in detail. Then the results obtained with the implemented prototype are presented in the *Results* section. Finally, last section presents conclusions and some guidelines for future work.

STATE OF ART

To generate virtual road environments, that fit the realism imposed for scientific driving simulation applications, a terrain model definition is required, where the road network can be implemented (Campos, Leitão, & Coelho, 2014; Campos, Leitão, Pereira, Ribas, & Coelho, 2015b; Campos, Leitão, & Coelho, 2015c). To generate terrain model definitions, typically known as digital elevation maps (DEM), several approaches have been suggested and developed. Although most known methods are suitable to generate terrains that can be used in several simulation applications, most of them do not allow the correct adjustment of the terrain required after imposing an externally designed road.