VISUAL DATABAE DESIGN FOR DRIVING SIMULATION

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To my beloved Mother and Father

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ABSTRACT

This research focuses on the development of a Visual Database (VDB) for a real time driving simulation (DS) to be integrated with other simulator components like the vehicle dynamic model (VDM). The integration of visual database with other driving simulation elements is useful for wide ranges of experiments and investigations related to vehicle simulation. To achieve an accurate driving simulation, virtual environment (VE) shall be constructed similar to the real world in a relevant framework using the applications of virtual reality (VR). In this project, the graphic quality and speed are optimized using different techniques in order to enhance the realism and fidelity of the simulation. The visual database and vehicle dynamic model are integrated through an interfacing system. The visual database was developed in a customized framework, which allows interaction of different computer in a distributed environment. A collaborative network system is required for high speed connection between different parts of driving simulation in order to have real time simulation.

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LIST OF ABBREVIATIONS

2D	-	Two-Dimensional
3D	-	Three-Dimensional
ADO	-	ActiveX Data Objects
CCAD	-	Center for Computer-Aided Design
CAD	-	Computer-Aided Design
CD-ROM	-	Compact Disc-Read Only Memory
CPU	-	Central Processing Unit
DS	-	Driving Simulators
FHWA	-	Federal Highway Administration
GHz	-	Gigahertz
GUI	-	Graphical User Interface
H	-	Heading
HYSIM	-	Highway Driving Simulator
IDS	-	Iowa Driving Simulator
ITS	-	Intelligent Traffic System
IP	-	Internet Protocol
Jscript	-	Java Scripting
LAN	-	Local Area Network
NADS	-	National Advanced Driving Simulator
NHTSA	-	National Highway and Transportation Safety Administration
NHTSA	-	National Highway Traffic Safety Administration
OLE	-	Objected Linking and Embedding
OLE DB	-	Object Linking and Embedding Database
P	-	Pitch
PC	-	Personal Computers

R	-	Roll
SDK	-	Software Development Kit
TCP	-	Transmission Control Protocol
TMS	-	Traffic Modeling System
UTM	-	Universiti Technologi Malaysia
VB	-	Visual Basic
VBScript	-	Visual Basic Scripting
VDB	-	Visual Database
VDM	-	Vehicle Dynamic Model
VTI	-	Vehicle Transportation Research Institute
VE	-	Virtual environment
VR	-	Virtual Reality

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Virtual Reality (VR) is used in a variety of ways in engineering and consists of many applications in business and different sciences [1]. VR applications are specialized simulations that allow users to interact in virtual environments in real time [2]. One of the fields in which VR has become very important is the development of driving simulators (DS). Driving simulation supplies a practical tool for studying the reaction of the drivers and vehicle behavior without using a real car in a dangerous condition. Using DS, engineers and scientists can save time and costs. Therefore, usage of driving simulation for vehicle design, driver perception and medical research is increasing rapidly [3].

Some American automotive companies developed driving simulators using flight simulator technology in the early 1970s. In the following decade, the first advanced models of driving simulation were constructed and this technology was later distributed in other parts of the world including Europe. General Motors [4], Daimler-Benz [5], Renault, Ford [6], Chrysler and the Swedish transport institute [7] were among these companies. During 1990's, many universities began to develop driving simulators as well. The Iowa and Virginia State Universities were the early

contributors in this field. Although the computer technologies have advanced and become cheaper nowadays, the development of driving simulators is still an expensive business [8]. The National Advanced Driving Simulator (NADS) is the most expensive and advanced driving simulator developed in the USA [9].

Driving simulators (DS) offer a number of advantages over other testing environments. A complete control of environmental factors is feasible using DS. Using this advantage, the experiments can be highly cost-effective for setup and data collection. While test conditions for vehicle behavior studies may be too dangerous in a real-world environment, simulators provide a safe environment [10]. Advancement in computer and graphics systems improved the virtual reality technology to simulate driving behavior of the real vehicle. Using advanced VR technology, Driving Simulation is no longer dangerous for the human drivers or too costly for the expenditure overheads [11].

Having the advantages of safety and economy, driving simulators are employed as effective research tools in several areas including automotive industry, traffic control, driver behavior and academic research fields, in addition to training novice driver and recreational computer markets [8]. In automotive industry, DS can be utilized as a tool for estimating the results in vehicle design process. It can evaluate different factors such as road holding characteristics, tire resistance, suspension issues and fuel consumption [4, 5]. In the investigation of driver behavior or human reaction, the effect of alcohol, drowsiness and usage of cell phone can be studied [12]. Training type simulator can accurately imitate the driving behavior so that the user can acquire the same experience as the real vehicle training which in turn enhances the training's quality and efficiency [13, 14]. Using DS in transportation [15], the use of in-vehicle equipments such as intelligent cruise controls, advanced collision warning, traveler information systems, and heads-up displays can be investigated. Driving simulation can also provide some medical experiments, for instance, studying the effect of drugs on driving and using multifocal lenses [16].

Driving simulations are divided into three different levels including low-level, mid-level, and high-level. Personal computers, pedals, and steering wheels are typically used in low-level simulators. Mid-level simulators usually include a motion platform and visual display linked with one or several computers for data collection and study. High-level simulators, which consist of Stewart platform or hexapod for support of movement and orientation, are more advanced and sophisticated simulators [17, 18].

Although engineers and scientist develop driving simulations in different levels, same components should be utilized in most of them. The main components of DS are driving control devices, Visual Database (VDB), Vehicle Dynamic Model (VDM), visualization devices and communication network system [1]. The driving control devices receive usable commands from driver. Visual Database sets up the driving environment and the interaction between simulated vehicle and surrounding objects. Vehicle Dynamic Model is a motion generation component, which computes the driving motion of vehicle. The visualization devices describe the behavior of a vehicle as graphic images on a screen or desktop of a computer. The communication network system communicates different parts of driving simulation [8].

One of the important aspects of DS is the presentation of the driving environment, which is similar to real world. In this project, we try to develop a visual database for driving simulation in order to the simulate traffic system in Universiti Technologi Malaysia campus. The UTM Driving Simulation consists of four main components - vehicle motion, visual database, control devices and communication network system between visual database and other components. In this research, we mainly consider the virtual environment (VE) and the simulated vehicle interaction with the surrounding environment. Research conditions are always safe and controlled, unlike on the road, where weather conditions and other factors will influence results. The vehicle dynamic model was developed by [1] and we used it in this project.

1.2 Problem statement

Driving simulator can be used for different purposes. The first issue to be addressed in driving simulator system is the price of the whole system. In recent years, computer technologies have advanced significantly, became cheaper, and can be used to develop low-cost driving simulators.

The second issue to be addressed in this project is the simulation of vehicle motion in virtual environment. Accurate driving simulators consist of many degrees of freedom and aspects; therefore, they can be too complex. Vehicle Dynamic Model (VDM) is used to analyze vehicle motion and study different driving behavior and vehicle estimation. As we consider using the driving simulation for controlling the traffic, analyzing all aspects of vehicle motion are not needed. Furthermore, limitation in PC ability and required equipments does not allow us to consider all aspects of vehicle motion. To solve this problem, six degrees of freedom model will be used and other issues like suspension will be neglected. The development of vehicle dynamic model (VDM) is explained in [1]. Vehicle position (x, y and z) and orientation (heading, pitch, and roll) are the six degrees of freedom used in the project.

The third issue to be considered in driving simulation development is simulation fidelity. Depending on the driving tasks, which should be studied in the DS, different fidelity could be used. Only few driving tasks are considered relative perceptual fidelity focus on specific types of comparisons between the virtual environment and real world. In contrast, absolute simulation fidelity may be needed when human perception or handling is studied as a function of road, visibility conditions and vehicle or traffic conditions. Recent technological advances make it possible to create simulators with increasing levels of physical fidelity. An unexamined assumption is that higher levels of fidelity will produce better DS outcomes, more precise assessments, and clearer insights into driver performance. In fact, low fidelity simulators or simulators that intentionally distort the driving

experience may be more effective than those that strive for a veridical representation of the driving environment and vehicle dynamics. This perception has important implications for scenario design, scene rendering, and motion cues. Although high fidelity representation of environment is closer to real world, it is not efficient to simulate the environment in real time. In this research, reasonable fidelity system was used using desktop PC that produces almost real time simulation. Three-dimensional based objects will be utilized in our driving simulation. Then, we use a two-dimensional photograph to map on the objects and represent the environment. As low fidelity is used, the improvement in speed is achieved. [3]

Realism performance is one of the essential issues in development of visual database. Collision detection in traffic system is the most important realism factor in this project. The forth issue to be outlined is the collision detection between vehicles and different visual database in a virtual environment. In order to represent our driving simulator accurately and close to the real world, the objects should be able to collide. If objects could pierce each other, the driving simulator does not have acceptable fidelity and cannot be used for traffic system analysis. The solution to this problem can be achieved by using a practical program that defines specified distances between objects. The distance between the objects should not be reduced from this marked distance. Therefore, as objects become closer to each other's the software delimits the distance between them and does not permit them to become closer than the defined distance.

The fifth issue to be addressed in this research is the extraction of data and development of a collaborative system for having a connection between driving simulation and an intelligent traffic system. It is desirable to extract the position and orientation from driving simulator in real time and export this information to other simulator component using communicable platform. So that data can be exchanged between subsystems of DS.

1.3 Objectives

The goal of this project is to develop a visual database system for real-time Driving Simulation, which can interact with other driving simulation components such as VDM and traffic modeling system (TMS). It is desirable to extract the vehicle motion data in order to have a connection between the visual database and other components. The objectives of this project are:

i. To design a visual database based on topography of UTM campus
ii. To produce a real time vehicle simulator with realistic virtual environment
iii. To develop a method of interaction between Visual Database and VDM

1.4 Scope of study

The visual database that is needed in this project was modeled based on the topographical map of the Universiti Technologi Malaysia. We have most of the objects, therefore all we need to do is to put them together and construct the virtual driving environment. The following aspects shall be the scope of the driving simulation:

i. Construction a visual database system based on UTM roads and environment
ii. Development of visual database using EON Studio ^{TM} [19]
iii. Extraction of vehicle data and communicate them with traffic control system and VDM