Interface for Virtual Automotive Route Creation in Driving Phobia Treatment

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Abstract. This paper presents a research with the objective to develop an interface to virtual route creation, based on Virtual Reality techniques for driving phobia treatment. The main contribution of this system is its flexibility for route creation, allowing a customization of these routes, according to each patient profile.

1. Introduction

The use of virtual reality (VR) as a medical tool has been receiving increased attention during the last few decades [1], being used as a variety of psychological treatment, for example, depression treatment, age diseases, and phobia treatment [2].

The main advantages of using the Virtual Reality for phobia treatment, in relation to traditional treatments, are:

- The patient does not need to imagine the environment that causes phobia to him, because this environment is already shown on the computer screen;
- The therapy is safer and not embarrassing to the patient, because it is made totally inside the psychologist office;
- It allows the psychologist to gradually controls the exposure level of the patient to the situation that causes phobia to him;
- As this treatment uses just a computer and a VR equipment, it has a reduced cost, compared to in vivo exposure therapy;

There are many research projects that use Virtual Reality for phobia treatment, like [4]:

- Spider phobia [5];
- Flying phobia [6];
- Agoraphobia, or phobia of open spaces [7];
- Post-Traumatic Stress Disorder [8];

A special consideration can be made for driving phobia. In many cases, this type of phobia is a consequence of a post-traumatic stress [9]. Over the last fifteen years, researchers have begun to discover that a certain percentage of motor vehicle accident survivors developed a post-traumatic stress. It is verified that 39% of 158 survivors of severe motor vehicle accident presented symptoms of post-traumatic stress, and in a group of 92 survivors of car accidents hospitalized in Australia, 25% of them presented symptoms of post-traumatic stress.
Driving phobia is presented as a great personal upheaval. Considering a person who is afraid of snakes, for example, this phobia does not cause great problems, unless he goes to a zoo that has snakes, because it is hard to find one of them regularly, and avoiding them is relatively simple [10]. However, the ability to drive a car represents a basic component for an independent life. Therefore, driving phobia can cause a great impact in the personal life of the patient, affecting his work, leisure, even domestic activities [11].

Several VR systems to driving phobia treatment can be found. Amongst the limitations of these systems, there is the non-flexibility in route creation (to be experimented for the patient during the treatment). Generally, these systems have previously constructed routes, with elements like streets, pedestrians, tunnels, houses, etc., but they do not allow modifications on their position inside the virtual route, nor addition of new elements.

Some of these systems allow the psychologist to modify traffic conditions, choosing routes with different pedestrian and car traffic, or modify climatic conditions of the route. Therefore, there is no way to combat all the elements that causes driving phobia, because these systems do not offer routes that include all of these elements. Besides, the same routes have to be used for all the patients. It is not efficient, because each patient develop driving phobia for a particular reason.

The VR building systems that can be adapted to be used in construction of customized virtual routes had not been developed for this intention, and therefore, have interfaces that tend to be complex and non-intuitive for a psychologist. Therefore his work becomes less efficient.

Another disadvantage of the current systems, especially those in which a real car is combined with projectors that show the environment used to the treatment [12], is the high cost of acquisition. In these systems, the involved peripherals are expensive, resulting in an onerous treatment for the patient.

2. Related Systems

Following, some systems that use Virtual Reality in driving phobia and transit simulation are presented.

DriVR [15] is a computational system to driving phobia treatment that uses a 3D scene generator software, connected to driving devices and a Virtual Reality glasses.

DriVR offers functionalities like patient performance measurement (as he navigates through the route), visualization of covered routes (allowing the psychologist and the patient to review the covered route by an aerial viewpoint during the treatment), a route builder that makes it possible to determine the complexity of the routes, and choose their environments, and an external conditions selector, allowing to configure climatic and road conditions, and route illumination.

The main disadvantage shown by DriVR is the poor flexibility offered by its route builder. It does not allow the creation of new routes, and the psychologist can just combine existent routes (increasing the total length of the route) and configure environment conditions, like climatic and road conditions.
Cave Lab Driving Rehabilitation Project [12] uses a system in which a real car is connected to software that generates a virtual environment with a route, covered by the patient. The system has, besides the software, a projector that shows the environment to be covered, speakers used to reproduce the sounds of this environment, and a sub-woofer system situated underneath the driver seat, to generate vibration effects during the treatment.

The virtual environment generated by the system presents characteristics like access to streets and avenues with huge vehicle traffic, streets with just a little or no traffic, random pedestrian circulation on the street, and the presence of other controlled vehicles, like cars, buses, etc.

This system uses a real car during the treatment, and because of this, has a high acquisition cost. Besides, it does not allow using other real cars, unless they pass for a modification, harming the system portability. But its seriously problem is the absence of a route builder, hindering the psychologist to do the treatment using different routes of the presented for it.

STISIM Drive [16] is a system for transit simulation, built to represent cognitive activities and common transit tasks. The system presents a vehicle dynamic model – allowing the configuration of characteristics of wheel and velocity control and defining vehicle gear system. Besides, it allows route visualization, through utilization of monitors or projectors, and through utilization of Head Mounted Displays (HMD).

This system also has a scenario definition language that allows the user to create routes described in the format of an event file, enumerating all the tasks to be done, and possible events to happen in the scenario.

Another feature of the STISIM Drive is the possibility of performance measurement. It allows the evaluation, for example, of the time of collision with other cars or pedestrians, the number of times the velocity limit was exceeded, the total time spent to cover the route, number of accidents, etc.

The seriously disadvantage of this system is the scenario definition language, used to build routes. It is based on scripts, and although it is powerful and flexible, allowing the creation of several types of routes, it is not intuitive to users without knowledge of computational programming, like psychologists, and this work can become extremely hard for them.

3. System Architecture

Considering the limitations found in systems presented, it is proposed, by a multidisciplinary group composed by psychologists, system analysts, and software engineers, to develop a system to assist in driving phobia treatment. This system is characterized for:

i. Presence of Virtual Environment simulating real routes, covered by a driver in a car;

ii. Low acquisition cost, so the treatment becomes financially interesting for patients;
iii. Flexibility on creation of experimentation routes, compatible with individual needs of each patient, and allowing to the psychologist to attend all the profiles of patients of driving phobia;

iv. A route builder interface that propitiate an abstraction level next to human natural language, allowing the psychologist (that most of the time does not have an advanced knowledge about computational systems), to construct their routes simply and intuitively, without worrying about techniques of Computer Graphics, Virtual Reality and Computational programming.

The system architecture is presented on the Figure 1.

Psychologist will interact with the **2D Route Creation Interface** to construct his route, and could manipulate transit elements deriving from a transit elements library. The system will then construct a set of 2D definitions, corresponding exactly to the elements organized in the interface. This set of definitions will be passed to the **Interpreter**, that will generate a file (in X3D format) containing 3D definitions corresponding to the automotive route.
The X3D file containing the 3D virtual route is composed of references to 3D objects also deriving from a library. For each 2D element on 2D elements library, there is a correspondent 3D object in 3D objects library. Therefore, the 3D virtual environment does not need to render each of the structures constituent of the automotive route in execution time, it just need to reference it in this library, loading its basics characteristics and configuring its specific parameters, in order to use it in the virtual environment in the adequate way. This representation schema in the virtual environment, based in using objects from a library, instead of generates it inside the virtual environment, makes the route definitions simpler, and allows a faster interpretation of its structures.

4. System Overview

The proposed system follows two basic principles: provide high flexibility to the psychologist, so he can create customized routes, according to each patient profile, and show a simple and intuitive interface, so this psychologist has no difficulties on the construction of these routes. Besides, the system must be capable of completely map the route constructed in 2D – a draw made by the psychologist, after studying what his patient really fears when he is driving – to a virtual environment, totally in 3D, automatically transparent to this psychologist, so it is not necessary to him to have any knowledge about Computer Graphics, Virtual Reality and computational programming.

Figure 2 shows the main screen of the route builder interface. In the window, the psychologist can access a variety of elements – widgets – to compose the route, that he can chose and insert in a drawing area, located in central part of the window. After insert an element into the drawing area, the psychologist can manipulate its properties. Each element has specific properties. Thus, a street can be two ways or single way, be totally smooth, or have some holes, etc.
In order to configure the external aspects of the route, like traffic and climatic conditions, the psychologist can use the configurations windows, presented on the Figure 3. In these windows, it is possible to configure if the vehicles traffic will be high, if the route will be covered at night or in the morning, etc.
For some elements of the routes, like buildings, it is possible to choose amongst models already defined. It allows a variety of these elements inside the route. These choices are made on the model selection windows, presented in Figure 4.

![Figure 4 - Models of houses, buildings and stations](image)

After the construction of the route, using the interface, the system will generate a 3D virtual environment automatically. Figure 5, Figure 6 and Figure 7 presents examples of virtual routes generated by the system.

![Figure 5 - Aerial Vision of the Route](image)
5. Implementation

Borland Delphi was used to develop the Route Creation Interface. As it is a RAD (Rapid Application Development) tool, it was not necessary to implement buttons, menus and other elements of this type of visual interface. Besides, it is a spread out tool between software developers, what facilitated the resolution of eventual doubts appeared during the construction process of the interface. This tool became possible the construction of the drawing area and the element properties configuration section. Moreover, it made possible the construction of a code whose execution demonstrated good performance, even for routes with a high number of elements, revealing thus, to be a good choice for the construction of this interface.

Borland Delphi has a component that manipulates XML structures, called ICOM XML Parser [18]. It organizes all nodes of an X3D file in a hierarchy of classes. Thus, the XML document is structured in a class, composed by XML Elements. These XML elements can accommodate several attributes, and have children that are also XML
elements. All the structure of the document is stored in a class named *Parser*. This class has a method that generates the XML file, based on the structured created. This component was used to make the transformation of 2D structure conceived on the interface in a set of 3D objects definitions, organized in an X3D file, using XML format.

*VizX3D* [17] was used to implement all the 3D structures of the 3D transit elements library. This tool has a visual interface that allows real time manipulation of the object modeling process, and has functionalities that allow several modeling methods like CSG [19], extrusions and geometric transformations, as well as manipulation of the appearance and behavior of created objects. Moreover, this tool contains specific controls and functionalities to construct X3D virtual environments, what made possible to generate the code according to this format, automatically and transparent.

6. Results

With the objective to verify if the system reaches its objectives, specially relating to the usability and simplicity of the Route Creation Interface, it was presented to a group of psychologists that act in phobia treatment area. After a period of utilization of the system by this group, its members answered an evaluation questionnaire. The following results were obtained:

1. **Disposal of the functionalities of the Route Creation interface:**
   
   None of the psychologists encountered difficulties to find and use the functionalities of the interface

2. **Traffic elements to be used in virtual routes:**
   
   All the psychologists thought there were enough traffic elements to build an automotive route and do the treatment.

3. **Manipulation of traffic elements in drawing area:**
   
   One of the psychologists had difficulties to manipulate the traffic elements in drawing area. He observed that the systems sometimes did not decide the best position of the elements automatically.

4. **Relation between the graphic representation of traffic elements and its functionality, in drawing area:**
   
   One of the psychologists reported that, sometimes, he encountered some difficulties to determine, looking at a traffic element, its functionalities.

5. **Configuration of traffic elements properties:**
   
   None of the psychologists encountered difficulties to use this functionality.

6. **Configuration of external conditions of the route (Climatic Conditions and traffic conditions):**
   
   None of the psychologists encountered difficulties to use this functionality.

   The following suggestions were presented during the evaluation period:
• A window containing a 3D route miniature version, acting as a map, so the patient or the psychologist can visualize the car position inside the route;

• A set of previously constructed routes, acting as route templates. At this way, the psychologist can initialize the route construction from beginning, with no positioned elements, or load a previously constructed route, modifying it or inserting new traffic elements.

7. Conclusions and Future Work

The use of Virtual Reality as a medical tool, especially in phobia treatment, has been showed to be promising, with a great growth market, especially in big cities. Beside, it does not need of complex systems, nor high acquisition costs equipments, and allows a treatment without risks and constaints for the patient.

The work presented in this paper proposed the resolution of two main limitations of the existent driving phobia treatment systems: the attainment of bigger flexibility in the creation of routes to be covered for the patients during the treatment, and a simple and intuitive route builder interface, in way that any knowledge about Computer Graphics, Virtual Reality of computational programming techniques is necessary to this process.

The use of Borland Delphi revealed to be adequate for the construction of the Route Creation Interface. X3D, used in the virtual environment, presented some limitations in the resources that treats input commands from external devices, like keyboard and mouse, becoming the virtual environment navigation limited. The main problem is that this resource only accepts one input command at a time. Moreover, the software used to run virtual environments in X3D needs an improvement on its functionalities, specially on textured objects visualization, that sometimes presents imperfections, and in sound files execution, that sometimes fails. Despite these problems, X3D propitiated navigation inside the virtual route, revealing to be enough to reaches the objectives of the project.

The traffic elements organization strategy during virtual route construction was based on a class hierarchy, facilitating the manipulation of its elements properties. The virtual environment was structured in a set of references to previously constructed objects located in a library. This type of organization became the virtual route code simple and efficient, also increasing virtual route execution speed.

The evaluation of the system by a psychologist group allowed concluding that the interface, even being a prototype and presenting some limitations, reached the expectations and aspirations of these professionals, configuring itself as a tool of easy adaptation and use.

As the system is been developed, and after its development, at the moment of implantation and appreciation of the user, many ideas appears, with the objective to make system characteristics better, or add new functionalities to him. Following, some adjusts and improvements are listed, and could be implemented in future.

• Patient performance measure: it would be a great advance if the system was capable of measure and present patient performance data, like exhibition of
average speed of the car during the route, total kilometrage, if he exceeded the maximum speed allowed, or if he caused an accident.

- **Biofeedback**: the system could be equipped with biofeedback equipments, allowing the measure and exhibition of the cardiac frequency, the breath and the level of anxiety of the patient, what would facilitate the decision of the psychologist about the evolution of the patient in his treatment.

- **Improvements in the Route Builder Interface**: it is important to improve the dynamicity of the graphic representation of the elements showed in the drawing area, through the implementation of a functionality that allows altering its graphics representation at the same time the psychologist alters its properties. Moreover, it is thought about the insertion of new transit elements, to propitiate a better realism to the generated route.

- **Creation of a route builder script language**: aiming the use by users with a higher computational programming knowledge, it would be important to create a route builder script language, allowing to these users specifying these routes through text files. These files could be based on task sequences to be done in the virtual route, or based on a textual description of the organization of the objects inside the route.

- **Improvements in the 3D Virtual Environment**: In order to make the 3D virtual environment closer to reality, it is interesting to make its actors with some intelligence, and having unexpected movements. In this way, it would be interesting to add more offensive and negligent pedestrians, or drivers doing risky maneuvers. Moreover, a better realism in the 3D virtual route can be achieved by the use of more sound files to be reproduced in the route.

8. References


