TV SPORT BROADCASTS: REAL TIME VIRTUAL REPRESENTATION IN 3D TERRAIN MODELS

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ABSTRACT

To enhance the understanding of sports competition broadcast, or to give viewers more information than just images taken from cameras, graphic representations are more intuitive and have greater impact than alpha-numeric information. This paper presents the characteristics and real television broadcast results of a project aimed to improve the understanding of an outdoor sports competition using virtual reality techniques. The system developed does not require any special hardware, which would have made the prototype much more expensive. This goal has been achieved using some new techniques and technological adoptions that are explained in the paper.

***Index Terms*—** TV broadcasting, Real time systems, Virtual reality, Three-dimensional Rendering, Geographic information systems.

1. SYSTEM OBJECTIVES

The idea was to generate a real-time simulation system of an outdoor sports competition. So, the system had to be capable of showing both a 3D geographic model of the terrain and dynamic objects, as well as locating the latter on the terrain depending on the real position of each participant in real life.

In addition to this, more information to improve the viewers' understanding of what goes on during the competition had to be added to the simulation. The first prototype we have worked on is for boat races. In this case, the additional information consist of the visualization of each boat's channel, the routes they take and other details.

To be able to broadcast the simulation video to all watchers, the frames created by the system also have to be sent to the mobile broadcasting unit.

The most outstanding characteristics of the developed system are listed below:

- It can be used for numerous outdoor sports competitions.
- It can handle heavy 3D terrain models (up to 2GB).
- Realistic simulation.
- Good operation in real-time.
- Insertion of additional objects and information to the final image enhances audience understanding.
- Versatility in the use of the participant localization system.
- Highly compatible with professional television platforms.
- Uses common hardware.

2. SYSTEM DESCRIPTION

2.1. Overview

The general architecture of the platform is shown in the figure below:

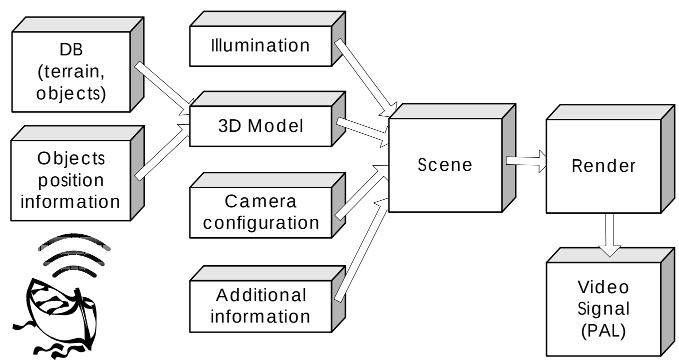

Fig. 1. System architecture.

2.2. Modules

In this section the functionality of each of the system module is explained:

Object database A database with all the objects that make up the scene has been created. Apart from the participants, the beacons and the terrain, we have also created a spherical sky to bring the simulation closer to reality.

Object Positioning The terrain information is georeferenced and to position the participants correctly on the terrain, we need to know their geographic coordinates. So the participants' dynamic positions must be obtained with reference to a specific localization system. This information is regularly transmitted to the calculation and processing centre in order to create the simulation.

3D model Both the database and the information about the positions of the objects make up the sports competition 3D model. The position of the objects in relation to the terrain is updated with the information obtained by the *Object Positioning* module.

Illumination The 3D model is illuminated depending on the time the competition takes place as well as the weather conditions at the time of the competition.

Camera configuration This module works as a virtual camera from the point chosen to visualize the 3D model. These virtual cameras provide views which help the understanding of the competition more than the physical cameras' views. As seen in Figure 2, in a rowing race the pictures the helicopters take do not always correctly show the boats' relative positions.

Fig. 2. Images catched from the helicopter.

The virtual camera keeps track of each of the boats and it can be positioned just above or on their left or right-hand side. This localization of the cameras gives viewers a very good understanding of the participants' relative positions. The camera can also be positioned just in front or behind the boat and can move around each of the boats.

Additional information Information concerning the distance the boats have to cover, the distance they have already covered, the route they are following and the number of the lanes they are assigned are added to the scene. This information, which is updated depending on what the boats do, helps to improve understanding.

Scene The scene is a graph of a hierarchical relationship between objects [1][2]. In this case, the objects are the 3D model (made up of the scenario, the moving competitors and the channels), the additional information objects, the virtual cameras and the illumination objects.

Render This is the module where the frames are created. This consists of a computation process in which all the 3D information contained in the view taken by the virtual camera is projected onto a frame. This is a very demanding process and so optimization techniques are required in order to get the real time performance.

Video signal The system provides a video signal as the output that the TV broadcaster delivers. So, this video signal complies with the broadcaster's graphical requirements and signal quality specifications.

2.3. Scene configuration

The scene composition has been designed in order to make the watching experience as realistic as possible. The scene objects are represented in Figure 3 and the objects defined in each module are specified.

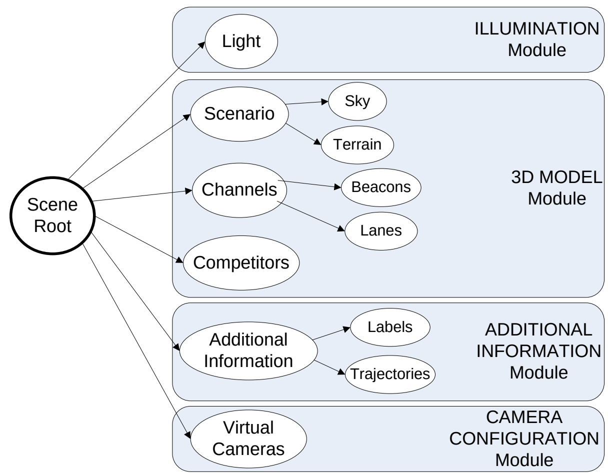

Fig. 3. Objects that form the scene.

We have created a terrain database with elevation information and orthorectified aerial photographs of the area of interest obtained from the latest official measurements[1]. The high resolution of these images (1 metre per pixel) makes the virtual representation of the scenario more photo-realistic. We have also designed a spherical sky object that wraps the terrain in an animation that makes it rotate to simulate the rotation of the earth.

The channels are regulated in the competition and the organizers place beacons on the sea marking the start and end of each boat's lane. The three-dimensional model we have designed contains 3D models of the beacons designed following the geometry of the real ones. And, to improve understanding of the competition, we draw the lanes in the virtual scenario. These lanes are also labeled with their respective dynamic numbers and are visible to all the virtual cameras.

Finally, the 3D models of the moving competitors have also been designed following their real geometry.

In addition to the 3D model of the competition, further information concerning the status of the competition and mentioned in section 2.2 is added to the final scene.

[1] http://www.ejgv.euskadi.net

The virtual cameras are also objects on the scene. Despite not being visible in the final image, they are used to select the view from where to render the scene.

3. IMPLEMENTATION

The system's most demanding issue is the rendering engine. The rendering is the computational process of generating an image using 3D information. Firstly, this 3D information is converted into polygons and then into triangles. Secondly, these triangles are projected into a 2D image and, finally, each pixel inside the triangles is coloured. The whole process takes too much time if no additional strategies or algorithms are used.

So we have researched the technology which enables the best performance in real time, taking into account the characteristics of the system planned as well as economic restrictions. We decided to make use of OpenSceneGraph[2] (OSG): an open source, cross-platform graphics toolkit for the development of high performance graphic applications [3][4]. It is based on the concept of a scene graph and uses OpenGL[3].

OpenSceneGraph makes use of techniques that speed up the rendering computational process because the rendering motor deals with considerably less information to obtain the same result to our eyes: a Level of Detail (LOD) algorithm, culling techniques (frustum, occlusion and small feature culling) and a State Sorting strategy.

The basic LOD idea is to use simpler versions of an object as it makes less and less of a contribution to the rendered image. So, when an object is far away, less polygons will be used to define it, which reduces the number of triangles to be processed in the rendering. The criteria OSG uses to select a level of detail model depends on the distance of the object from eye point (range-based selection). And to stop the switching form one LOS to another being noticeable, a Continous Level of Detail (CLOD) technique is used.[5]

Culling techniques consists of removing portions of the scene that are not considered to contribute to the final image. The rest of the polygons are sent through the rendering pipeline. With the View frustum culling technique, all the polygon groups that are outside the view frustum (the region of space in the modeled world visible form the eye point) are eliminated. When occlusion culling is used, all the objects hidden by groups of other objects are also eliminated from the sending-to-render process. And with Small Feature culling, small details that contribute little or nothing to the rendered images are not processed when the viewer is in motion.[5]

State Sorting consists of sorting geometrical shapes with similar states into bins to minimize state changes in the rendering process.[5]

Apart from the rendering techniques, OSG can manage a large set of data formats, including the most used 3D information files and image formats [3]. And, last but not least, it supports applications for handling Geographic Information and creating terrain databases.

With regard to the output signal, we have worked with a broadcaster that broadcasts the videos using the PAL system. So, we adapt the rendered images to this system's graphic restrictions. To do so, we adapt the rendered images with the Matrox[4] CG2000 video adaptor. This hardware combines a 3D graphic accelerator with broadcast quality video I/O.

DGPS (Differential Global Positioning System) is the localization system used to obtain the participants' positions and we estimate that the error is delimitated to a maximum of one meter. The way the DGPS receptor and a transmisor of that information are used depends on the particularities of each sports competition. In boat races, a device is mounted on the stern of each boat. However, in a cycling race this would increase the weight the participants have to cope with. In this case, it would be better to place the device on the motorbikes that follow the cyclists.

3.1. Terrain Database

The way the information related to the terrain has to be stored and handled by the processor is an important issue when designing systems with good real-time behavior because of the big terrain database often used. A terrain database contains information about both the height and orthorectified aerial imagery of the specified area. In our case, the height information is given in grayscale bitmap images.

High precision terrain-information is required to get a photorealistic simulation. Since database size increases with precision (in terms of the number of polygons and textures), it is necessary to make use of special techniques (already mentioned in section 3) to improve database management and, consequently, real-time behavior.

We have chosen the OpenSceneGraph graphics toolkit osgdem utility program. With osgdem it is possible to read geospatial images and digital elevation maps and create large-scale 3D terrain databases. A particularity of these databases is that the information is stored using the Level of Detail (LOD) technique, so the information level of detail is switchable depending to the user's position. So the size of a terrain database is not a problem for the system's good real time behavior. The database created by the osgdem utility program contains tiles for each of the detail levels stored.

4. SETTING UP AND RESULTS

In the summer of 2006 we tested the system in the most important rowing race in the Cantabrian Sea as well as in Bilbao estuary. The overall result was excellent, the system worked as expected on professional platforms and the output signal

[2]OpenSceneGraph Home Page: http://openscenegraph.org/

[3]OpenGL Home Page: http://www.opengl.org/

[4]Matrox Home Page: http://www.matrox.com/

was broadcasted live by the Basque public broadcaster without any problems.

We should emphasise that the "participants localization reception system" updates the information every second. Nevertheless, television viewers have a perception of continuous boat movement thanks to the algorithm implemented to predict the movements the participants make during that time. This algorithm is adaptive, in other words, it takes into account the participants' previous positions, speed and orientation.

In the Bilbao boat race we noticed that there were situations in which the coverage of the signal did not reach the receiver because of buildings. This caused problems that we resolved by estimating the boats' positions without signals using the above mentioned algorithm. When the time without coverage was longer than a certain period, we decided to remove the boat from the visualization. Later on, we tested the system again with this improvement and the results were very satisfactory.

In 2007 more tests were carried out and the results are shown in the next figures. The first one shows two moments of the broadcasted video (Figure 4) and second shows two views taken by the system (Figure 5).

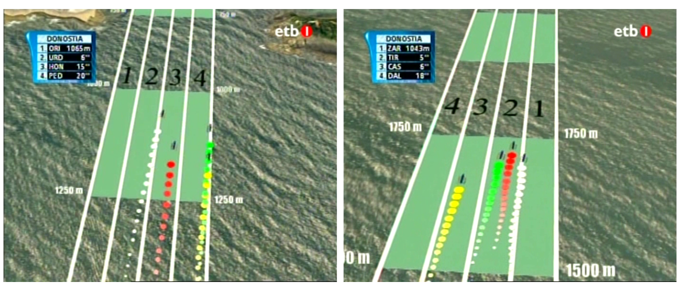

Fig. 4. Some moments during the broadcast.

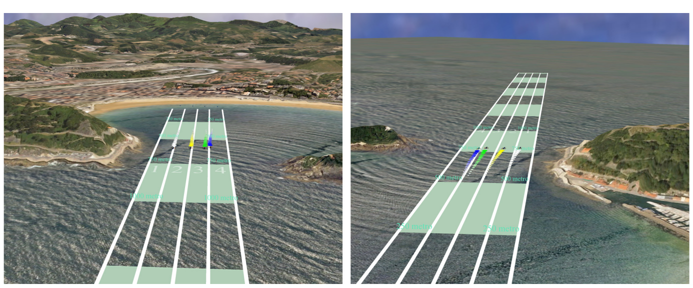

Fig. 5. Some views created by the system.

5. CONCLUSIONS

We want to emphasise the fact that this system works in real time has been implemented on professional television platforms and has no high hardware requirements. In fact, nowadays rendering optimization and scene description techniques are so advanced that real-time professional results can be obtained without using professional graphic processors.

Current state of the art offers other commercial solutions to obtain the participants' positions using fixed cameras and segmentation techniques. These solutions are not suited for nautical events owing to the physical restrictions for placing fixed cameras on the sea and the difficulties to extract the boats from the sea using image processing techniques. So this system, which uses a concrete positioning system device (DGPS) and virtual reality techniques, provides a solution to enhance outdoor sports competition broadcasts, while keeping the cost within reasonable limits as there is no high hardware or software requirement.

For television use, the quality of the images broadcast is particularly important. When a simulation of a real action is effected, viewers expect a realistic representation of what is happening. So for greater system acceptance it will not be enough to just increase the resolution of the height and images used for the terrain. Other tasks, such as the simulation of the vegetation, 3D buildings, atmospheric effects and the like must be included.

6. ACKNOWLEDGMENTS

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