Using Virtual Reality on WWW for Emergency Planning in Urban Environment

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Abstract

Italian ICIV Programme (Ingegneria Concorrente per l'Impresa Virtuale – Concurrent Engineering for the Virtual Firm) provides complex infrastructures, concerning tools and drives, in order to actively spread and support the concept of virtual enterprise. One of most representative project of ICIV is the realization of the virtual model, deployed on Internet, of Brindisi town, sea-port located in Southern Italy. This place has been selected because of its medium dimensions suitable to fulfill a high level of accuracy about its virtual representation. The VR model of Brindisi is limited to the historic nucleus of the town, featured by the typical topography of the Mediterranean cities (narrow and twisted streets, relevant presence of churches, market squares and so on). "Virtual Brindisi" however relies upon an Internet GIS database covering the whole district and moreover, it does integrate visually a traffic and environmental simulator able to reproduce in interactive way and, above

all, in the immersing way of the VR, phenomena as jammed roads, traffic pollution and other what-if scenarios.

ICIV-PIU platform, the name of the Project, has been especially studied for urban planners so to provide a powerful sharable instrument to analyze and manage the city. The city of Brindisi is divided, on the basis of well-formalized criteria, in sectors where each does represent a homogeneous block of buildings and for each of them a pool of information, resident on the Internet GIS database, is associated (data on transportation, business, social and so on). The blocks can be dynamically re-configured and/or aggregated in order to have new build-up areas so that new scenarios, related to private and/or public transport, can be simulated. The tools for the navigation and the manipulation of the VR model run as client session via a GUI interface starting from Browser and provide, for whoever on WWW owns access privileges, the possibility to recite the appropriate role: architect, mobility manager, city planner. So it is enough intuitive that this VR environment, containing a very impressive digital replica of the town of Brindisi, can be exploited for the training of emergency personnel. By extending the initial scope of the platform it could become possible to create a highly realistic image of a typical emergency in the city: for example, we can suppose a training exercise where an assigned location is restricted for local traffic and rescue team confides into find out the fastest routes to reach it. Flying via Internet through the VR model of Brindisi will become an easy task to familiarize, also for remote subjects in charge for emergency, with streets and buildings of this city in any traffic condition.

Figure 1: virtual fly through Brindisi town

1 Introduction.

The experience of Virtual Reality applied to urban structures is getting a great popularity because of the growth of the calculus power and, lately, for the deployment via Web of the technologies able to transport and visualize smoothly objects of 3D world. In Italy ICIV Programme - Competitor Engineering for the Virtual Firm - leads relevant applications, that normally work on local site, to operate on Internet as shareable platforms (or it creates fully new applications embedded in Web environment). A specific project of ICIV, named PIU (Piattaforma Integrata Urbanistica – Integrated Urban Platform) or **ICIV-PIU**, is designed mainly for the town planners but its technology is suitable for various purposes and in particular for the simulation of congested traffic during emergency situation in a city structure.

The platform ICIV-PIU is designed on a client/server environment that gives the possibility to subjects, that are geographically scattered, to benefit of Virtual Reality technology in collaborative way, applied to the specific case of Brindisi town. In fact different tools for simulation and evaluation of urban trends (flows of people and transport vehicles, alterations in environment and so on) are integrated in the platform and the presentation in Virtual Reality of the results of traffic simulations permits an immediate perception of transportation dynamics. More in detail, we have:

- mobility and environment simulation and impact of interventions on the urban planning
- integration of the 3D model and the simulation model in an application usable via the typical virtual reality tools (real-time visual simulation, on-line interaction, collision

detection and so on)

- training of personnel for planning of mobility and for study of specific crisis situation due to traffic

2 Rationale of ICIV-PIU Environment.

The requirement for ICIV-PIU was for a sharable platform able to provide support for traffic planning, design of new urban network configurations (see Fig.2) with intervention on vehicle circulation discipline, accessibility analysis, analysis of balance between mobility and the environment, studies on interactions between the urban configuration and mobility. Specific know-how has been acquired in the capability of developing models of the urban system encompassing innovative mobility regulation measures, such as: restricted zones, area and road pricing (cost of the movements), inter-multi-modality to improve the general performance of city network.
At complement of the numerical models to determine the behavior of the road transport system inside a city there is environmental simulator calculating the pollution of noxious substances and noise generated from vehicles traffic. In such way ICIV-PIU platform does provide a full range transportation simulator with meaningful capabilities to assess and predict the environmental impact of proposed modifications to the current traffic situation. Moreover the urban planners and the other subjects having jurisdiction on the urban territory can share, via Internet, all the hypothesis for remedial actions and mitigation measures.

The main applied technologies are Java 3D language for VR engine operating on a customized sub-set of OpenGL library, an Internet GIS database, a traffic scenario generator based on a core written in Fortran Language. The interface of ICIV-PIU is startable as client session from a whatever Browser supporting the Java Virtual Machine. The requirements for client machines are the presence of a high-performance 3D graphic card supporting OpenGL and the pre-installation of VR environment containing the 3D model of Brindisi.

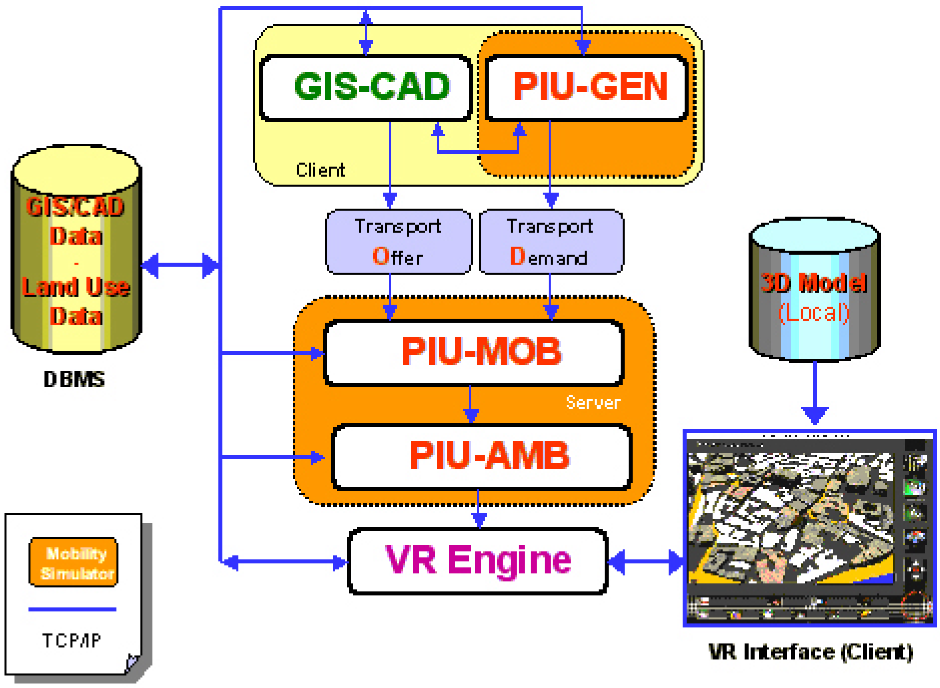

Figure 2: ICIV-PIU Architecture

3 Architecture of ICIV-PIU.

The system ICIV-PIU is based on the co-operation of three main subsystems (see Fig.2): the database logically organized around to a GIS standard application, the traffic simulator, the Virtual Reality environment. All these applications and related user interfaces are based on a client/server architecture and communicate via TCP/PI protocol working with the following modality of production:

- **Pre-process** with a intuitive GUI interface to be used for input of the data, urban intervention as traffic marshalling, building's modifications and specific requests
- **Process** (constituted of several modules) for numeric simulation
- **Post-process** with the graphical interface for the Virtual Reality with dynamic representation of the traffic simulation

3.1 Subsystem GIS/CAD.

The database of ICIV-PIU is based on a CAD/GIS application (see Fig.3). This subsystem usually works during the phase of pre-processing in order to:

- make and manage the CAD components of urban model by associating 2D items (lines, polygons) with the information related to the third dimension (altitude respect to building footprint, height when extrusion is applied, mapping of building faces, ...)

- manage social/economical and statistical information associated to site's objects (data on the urban population, the business, the infrastructures,…)
- create and manage a simplified network pattern related to the graph of roads, its regulation and transport's capacity
- start queries on the database, also during the post-processing phase, e.g. on the data produced from the traffic simulation models

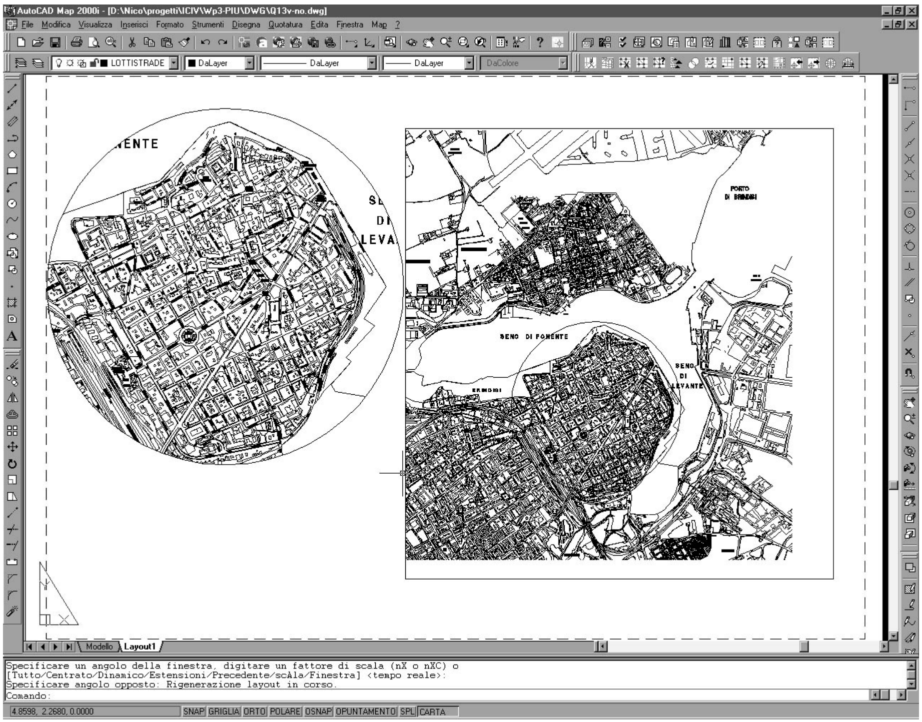

Figure 3: GIS/CAD subsystem Interface

In order to grant data consistency, an unique reference's scenario does exist, available for the System Administrator. So the users can play only with customized scenarios, recorded in private repositories. Thematic objects of the city, as buildings, roads and so on, can be modified by mean of Editor module, operating also in this case on a copy of data drawn from the GIS/CAD database.

3.2 Architecture of Traffic Simulator.

The traffic simulator, including both mobility and environment models, is based on three subsystems (see Fig.2): a scenario's generator, an inter-multi-modal mobility simulator, a environmental model for polluting substances given out from vehicles running on the arcs that interest the current simulation.

3.2.1 Subsystem to generate transport scenario.

The subsystem PIU-GEN contains a reference's model about the generation of demand of transport. This model does permit the calculus of the matrixes Origin/Destination (OD) that constitute the input for the model of simulation of inter-multi-modal mobility (see subsystem PIU-MOB), which output does constitute in turn the input for the model of simulation of environment impact (see subsystem PIU-AMB). PIU-GEN permits to create a matrix of movements (O/D), on the basis of zonal parameters where social-economical features are prominent, and that can be used to evaluate the produced effects coming from modifications of urban and social infrastructures.

3.2.2 Subsystem to simulate inter-multi-modal mobility.

The subsystem PIU-MOB is a traffic simulator based on an assignment methodology and evaluation of modal diversification in order to calculate routes and flows of passengers. As the most used assignment software, PIU-MOB has as input the definition both of the Demand (one or more matrixes Origin-Destination of possible total travels) and the Offer (a multi-modal transportation structure formally represented by mean of a graph of mono-modal and mono-directional oriented arcs). The simulation procedure consists to investigate the routes (mono and multi-modal) satisfying any O-D relation and, in iterative way, to restart on these, proportionally to a function of global cost associated to each route in order to refine the inter-multi-modal model.

More in detail, PIU-MOB subsystem does own the following features:

- inter-multi-modal network is represented from connection of arcs with mono-modal features; it is possible to define any number of transportation modality; three kinds of arcs do exist: transportation arcs (movement), arcs of transfer-exchange-wait, fictitious arcs connecting the centroids;
- for each O-D relation, the possible routes area are evaluated exhaustively with parametric research; the distribution of the flows on the routes is realized with probabilistic criteria on the basis of Logit formulation;
- the assignment is achieved considering the limitations of capacity and the reduction of the speed (growth of time) of crossing of arcs in function of the flows.

3.2.3 Subsystem to evaluate pollution of substances and noise.

This subsystem, named PIU-AMB, is finalized to simulate the diffusion of typical polluting substances generated from vehicular traffic in urban scenario. This subsystem is also able to simulate the noise on single arcs, representing the streets, generated from traffic. In order to have a realistic model of the phenomena of pollution, PIU-AMB does use transportation parameters (flows, speed and so on) measured directly on the road or calculated from a model of allocation of the vehicular traffic, previously produced from PIU-MOB subsystem. The pollution database (Corinair Method) and the data related to the meteorology and the configuration of the urban structure, permits to evaluate the diffusion of three polluting

substances and to calculate the energy consumption.
In analogy, the numeric simulation model of acoustic “pollution” does use data generated from a model of assignment of vehicular traffic and the information related to the configuration of urban structure and permit to evaluate, applying numeric algorithms, the noise level on the streets, and on the neighbouring area, to be studied.
The polluting substances, at fixed condition of motion, range for quality and quantity on the basis of several factors, as kind of fuel , used technology, cubic capacity, weight and so on. So, early the fleet of vehicular traffic is classified on the basis of Corinair Method, that subdivides vehicles in classes and sub-classes.
Concluding, PIU-AMB subsystem is able to evaluate:

- emission (CO, NOx) and energy consuming on the basis of vehicular classes and traffic conditions
- local concentration of polluting substances on the basis of geometric features of the streets and local weather conditions

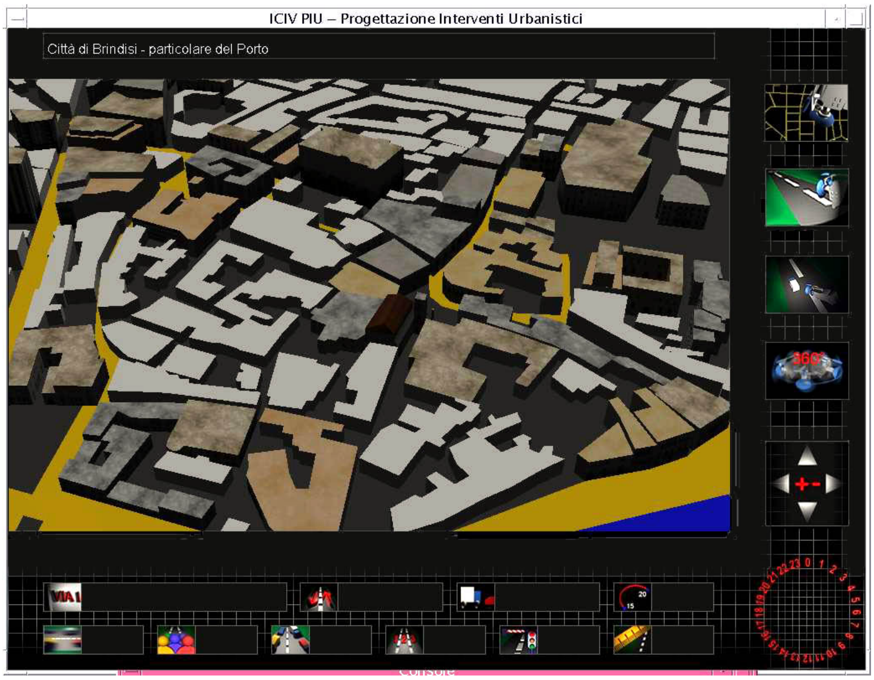

Figure 4: VR Navigator Interface

- diffusion of polluting substances at global level on the basis of weather conditions, current and forecasted
- noise emission of vehicular traffic

3.3 Technologies to develop Virtual Brindisi.

For the realization of the 3D model of Brindisi town has been selected Multigen Creator. The graphic format of this development environment is FLT (OpenFlight) that permits to manage

several features, only to cite the most important: the shading of the model, the LOD (Level of Detail), the DOF (Degrees Of Freedom), filtering, switch for small animation, hierarchical grouping and bounding volumes and so on.
The used language for the VR engine is Java because of its high portability. In particular, Java implements a 3D library managing 3D scene-graph and relies at low level on graphics cards based both on OpenGl and Direct3D drivers. Moreover Java does permit the interfacing with remote database by mean of JDBC (Java Database Connectivity) protocol so that it is possible to communicate directly, via networked native protocol, with DBMS server.

3.3.1 VR Navigator.

This component (see Fig.4) has the scope to permit a smooth supervision of the vehicular flows The available functions are:

- visualization of both global data of the model and specific data, for example the data related to the arcs by mean of picking operations on the same road arcs
- selection of a television camera's model and its setting, e.g.:
  a) camera named 'Radial' that permits to survey the scene from the top as a person flying above the city aboard a helicopter;
  b) camera named 'Fixed' that permits to set the same at level of street; this television camera can be used to survey the flows of cars at a crossroad;
  c) camera named 'Follow' can be positioned aboard of a vehicle and permits to visualize the scene as though the subject is inside of a vehicle going along a route;
- make camera's movements, zoom, in order to modify the visualized scene and observe with the detail's level that the user believe the most appropriate.

3.3.2 3D Editor.

This module, integrated in the GUI, permits to make operations able to modify a certain model of city starting from an existing model of Brindisi (scenario). The modifications to the model of virtual city are of two different typology:

Modification of a element's attributes: it is possible modify urban data and/or the data used as input for the simulation changing the attributes to one or more elements. For examples, for the traffic arcs will be possible modify data as:

- road conditions (street not accessible, one-way and so forth)
- crossroad's typology (free arcs, with semaphore, and so on)
- interdicted lanes for great arteries
- other relevant features about an arc's (street) discipline

Modification of the 3D model: It is possible to introduce in the graphical model a new punctual element (for example, a school): in this case will be need to have locally a commercial 3D development environment creating new graphical object. Afterwards all the requested attributes will be associated to the element. These attributes can be related to both spatial (x,y position) and social-economical information.

4 VR to simulate Emergency.

An obvious use of Virtual Brindisi is the training in operation of personnel for emergency. Errors during the training don't effect for the traffic and for the situation of crisis and the advantages are at the same time the growth of confidence with the specific features of the city. The experiences to visit in VR the city can be replayed until the emergency personnel is able to recognize streets and single buildings and the most usual traffic situations for each zone of city. Next steps of training stage can be complicated by selecting weather conditions and specific hours.

During the training sessions we can have two distinct human figures of emergency personnel:

- the planner. This subject should become able to visit VR Brindisi flying around and onto the city and to take a virtual tour of building blocks (see Fig.1). Typically the commitment of this subject is to manage the emergency and to direct the rescue squads in acceptable time
- the driver (typically a fireman). This subject should become able to drive, imaging his-self as driver of rescue vehicle, in VR city in order to reach established points as faster as possible and in respect of configured scenario (dawn, durst, regular traffic or not and so on)

The platform is designed to work on Web. So it is possible to outline the efficiency of the Project by using its applications on networks: it would even be possible for civilian emergency agencies (Italian Minister of Civilian Protection) and Municipalities to "virtually" work and drill together. The objective is a more realistic training and a continuous improvement of the capability of response to crisis situations that could happen in the city of Brindisi.

Specific training sessions for scattered manager and fireman are the most profitable way to use the platform. The manager, that does have also the commitment to configure the simulation, for example:

- create scenarios at various levels of difficulty
- create also unusual situations (e.g.: the traffic can be slowed from jammed intersection nodes and so on)

In this way the platform is used to check the level of confidence, of the rescue driver, with the plan and the buildings of Brindisi town and his ability to find out the better route with shortage of time available.

The highly involving experience of Virtual Reality will provide the needed realism to the training where a fast interaction around restricted zones is requested to emergency personnel.

5 Conclusions.

The technology trend and, first of all, the increase of the transmission's bandwidth does make desirable the use of VR on Web. The expected benefits of ICIV-PIU platform, exploiting it as new support tool for emergency for Brindisi town, will include several advantages:

- to allow, to planners and rescue personnel, multi-user training sessions facing these on own platforms with an appreciable gain of time into exchange critical information time depending
- to assess the results of traffic simulation in intuitive way (for example, remaining locked in the jammed traffic) sharing the information with other subjects operating on similar scenarios
- to enhance the interactivity and the multi-user cooperation into creating new scenarios
- to organize training sessions with all the team members simultaneously interacting across heterogeneous platforms.

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