# MULTIAGENT SIMULATION OF VIRTUAL 3D ENVIRONMENTS

## 1. SYSTEMS AND TRANSPORTS LABORATORY / LABORATOIRE SYSTEMES ET TRANSPORTS

Under the French Ministry of National Education and Research, and the University of Technology of Belfort-Montbéliard (UTBM), the Laboratory "Systèmes et Transports" (SeT) is a multidisciplinary host team (EA3317).

The SeT laboratory is composed of four teams:

- Computer Science (Communication, Agent, and Perception) Team (ICAP);
- Ergonomics and Design of Systems Team (ERCOS);
- Evaluation and Control of Systems Team (ECS);
- Energy Control and Conversion Team (CEC).

The laboratory aims to promote and apply Research and new methodologies in the field of transport, simulation and 3D modeling.

**This document presents the works that can contribute to the modeling, simulation, and evaluation of urban systems (indoor or outdoor).**

### 1.1 SIMULATION IN VIRTUAL ENVIRONMENT

Our project addresses the field of microscopic simulation of pedestrians or vehicles in virtual environments. This area is located at the intersection of many scientific disciplines: distributed artificial intelligence and multi-agent systems (MAS), geographical information systems (GIS), computer graphics and virtual reality. Indeed, we use the multi-agent systems to design and simulate the behaviors of intelligent autonomous entities and populate virtual environments. The aim is to simulate a large number of entities exhibiting a wide range of realistic and configurable behaviors. To increase the realism of the behaviors, the simulated entities own a perception mechanism, which is

inspired by the human sensors. Moreover, the virtual environment is used as a source of geometrical information (e.g. an obstacle shape) or semantics information (doors, walls, chairs, etc.). This information is then used in the decision process of each simulated entity to decide what action to proceed.

Our ultimate goal is to provide a whole process to design a simulation in virtual situated environments. Firstly, provided algorithms automatically generate the numerical models as much as possible. Thus, the information from geographic information systems is extracted to generate the accurate geometries of the 3D model. Different techniques are also explored in order to enrich the environment with the semantics of the objects. Finally, the virtual reality simulator enables the users to evolve in the virtual world and interact with the entities that are populating it. Additionally, the simulation tools must be run on a desktop computer, laptop and virtual reality platform. This constraint has a strong impact on the design of the simulation. Indeed, the simulation model must support real-time performances while maintaining a maximum level of accuracy in the simulation graphical and statistical results.

### 1.1.1 Three Classes of Application

Multiagent simulation is intrinsically non-deterministic. Consequently, this approach is well suited for the execution, comparison, and validation of simulation scenarios.

To illustrate the potential of the multiagent simulations, we can mention three main classes of applications in which we are particularly involved:

#### *Simulation for decision support or management of infrastructure.*

The evaluation of the displacements in a Public Access Building (PAB) whatever its nature (airport, train station, living room, open-air festival, etc.) are essential to ensure a proper usage. It is also the case for the evaluation of mobility in an industrial or urban area. Whether in a normal the simulation in a virtual environment provides models and tools to improve at the same time the evolution of the simulated building/area, and the design of this system during the pre-project stage. The simulation tools have to:

1. study the accessibility of the site;
2. optimize the routing of the flows within a building or a city;
3. validate the design and the implementation of an infrastructure during the preliminary design stages.

### *Simulation for the training of the staff in the field of the global security.*

As part of the training of crisis units, the simulator can be exploited to immerse a group of people in a realistic environment. It enables to validate their responses during critical situations, and the effectiveness of the safety procedures. This axis aims to evaluate the operational strategies through a set of repeated practice of crisis situations. These situations can be reiterations of past or actual incidents of extreme situations, which are impossible to reproduce in real size due to cost and safety constraints.

On this axis, our simulator can be coupled to a system of knowledge management. It enables the identification of the risks during daily and related interventions. It is also a support for feedback and to build a collection of specific indicators. These indicators allow the statistical monitoring and post-event-categorization of the incidents and the development of assessment reports on the responses of the trained during the virtual exercises.

On this class of applications, the ICAP team has proposed a project to the National Research Agency "Concepts, Systems and Tools for Global Security" (CSOSG). This project addresses the theme of the training of actors in crisis cells. A cell of crisis consists of a Departmental Operations Center (DOC) and a operational command post (OCP). The DOC is composed of the several actors: the prefecture, gendarmerie, police, and rescue and medical services. Depending on the type of crisis to manage, other specialized actors can complete the cell. The OCP is the forward command post in the field. DOC defines the strategy for managing the crisis. The OCP manages for its tactics and operations of the actions and interventions of the rescue units on the ground.

The project aims to specify and validate the scientific and technological components of a system to train the different actors of the Crisis Staffs. These elements will be developed in the most generic possible way and applied to specific types of crisis in Belfort. This area was selected as the testing department as the steering committee of the project integrates the four key services that make up its DOC: the prefecture, SDIS90, gendarmerie and police.

In this context, the research topics cover the analysis of social dynamics, behavior of crowds, behavioral simulation of populations, and various approaches to knowledge management.

The main objective of this project is to provide a training system for the stakeholders of the crisis cell. This system is composed of two modules: a microscopic simulation in a 3D virtual environment on one hand, and knowledge management on the other. This system will support different types of crisis. The crisis scenario will be determined during the project. This training system is designed to evaluate operational strategies through repeated practices of crisis situations through simulations. In parallel to simulations, the knowledge management module aims to build on the fly any knowledge about the decisions taken by the crisis units and their real consequences (derived from previous incidents), or simulated consequences.

### *Automatic generation of virtual worlds.*

The simulation of pedestrians and vehicles in virtual environments requires highly accurate 3D models representing the real environment. The work around the automatic generation of virtual

worlds is related to the generation of 3D models. However, they can also be used in other types of applications such as virtual visit, for example.

In order to generate these worlds with a small cost but with sufficient accuracy for the simulations, we use the available 3D data of the studied areas: data from geographic information systems, architect's plans, aerial photos, etc. The 3D models produced by the algorithms is based on the digital terrain model with an adaptable complexity; and on which the other objects are geo-localized (buildings, vegetation, etc.).

The algorithms produce a set of 3D virtual models, which are geometrically accurate and precise. They can be directly used during simulation; or they can be a basis for the graphic designers who can improve their appearance (skins with pictures of building's facades, adding details, etc.).

## 1.2 Platforms of the SeT Laboratory

### Platform for virtual reality simulation and project review.

Built around a screen of 2.4m per 1.9m, and fitted with a passive stereo system, the platform facilitates the review of projects through visual *immersion*. Incidentally, an optical motion capture system, through a master controller and a pair of glasses enable the user to interact with the 3D scene in real time. Additionally, a 3D spatial sound system enhances the user immersion.

### Platform for Intelligent Vehicle.

The laboratory has two GEM electric vehicles. These vehicles have been automated and can be controlled by an onboard computer system. With multiple sensors, these vehicles are able to detect and avoid obstacles and follow other vehicles (platooning). These work, conducted as part of the CPER (state region contract plan), are the results of collaboration between the ICAP and CEC teams. The next step is to develop a hybrid engine based on fuel cells.

The laboratory also provides a vehicle for experimentation. It is powered by four electric motors (one per wheel) and has four wheels can be moved synchronously or in opposition. Control is via an embedded PC. They have proximity sensors (stereoscopes, laser range finder, sonar, magnetic loop detectors, GPS, etc.) as well as vehicle communications (wireless Ethernet, GSM, etc.).

## 2. SEVERAL SIGNIFICATIVE PROJECTS

The following projects have been conducted in industrial transfer contracts.

### 2.1 THE TRANSPORT AND URBAN MOBILITY

#### SURE (Sustainable Urban REgeneration) 2002 – 2005

SURE is a research project supported by the European Commission. The consortium is made up of local authorities, universities and local development agencies of five European countries (Germany, Spain, France, Italy, and Poland).

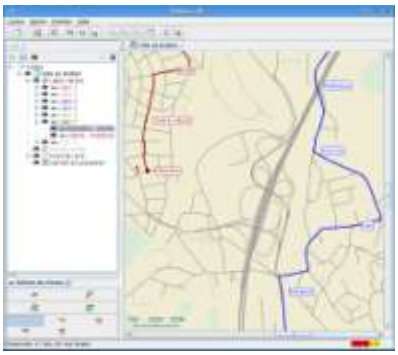
SURE is designed to meet the needs expressed by some European cities and their citizens, particularly in urban areas where the most sensitive social and economic transformations have given rise to new social and environmental problems, and urban (job loss and rising unemployment, declining public services, insecure neighborhoods, vacant lots and abandoned industrial sites, high levels of pollution, degeneration of public spaces). As these areas are currently faced with crucial choices regarding the redefinition of their characters, SURE intends to identify technical and organizational tools to help governments and local stakeholders in their development choices.

This project involves analyzing the problems of urban regeneration based on a spatio-temporal approach: it takes into account not only the economic and spatial indicators but also their evolutions over the time.

From a technical point of view, a prototype of representation and simulation of urban phenomena, especially in the area of mobility and accessibility, has been developed around a geographic information system by the ICAP team and the House of Time and Mobility of Belfort.

#### Decision-Making System for the Design and Analysis of Public Transport Networks: Software MetroB registered in the French Industrial Protection Agency (INPI) in 2006.

Transport networks are continually evolving to meet the expectations for safety, environment, quality and cost. The development of new transport solutions requires tools of analysis and simulation to facilitate there design. To meet this growing need, we have developed a system of decision support for the design and evaluation of public transport systems. This platform is called MetroB (Metro/Bus Simulation Platform). This software:



- provides user-friendly tools for the design and analysis of the data recorded on the real buses,

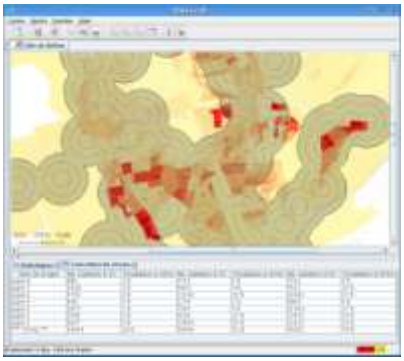
- evaluates the effectiveness of different transit networks from the point of view of the users and authorities,
- simulates new public transport solutions, to evaluate them.

The main goals of MetroB are:

- Clearly exposes the design solutions of a bus network to achieve a better communication among the project stakeholders and the users of the network.
- Evaluate a bus system to verify its feasibility and identify its advantages and defects. This innovative project has already shown its interest under the Urban Transport Plan of the city of Belfort.

MetroB is software composed of tools for viewing and editing geographical features on one hand, and evaluation and simulation tools, on the other hand. It allows to:

- edit the various proposals about the bus network;
- see the network in relation to the other geographic features such as the other transport networks (train, metro, etc.), and the attractors (schools, shopping centers, etc.);
- evaluate the bus network to identify its advantages and defects;
- simulate the behavior of the bus system to verify its feasibility.



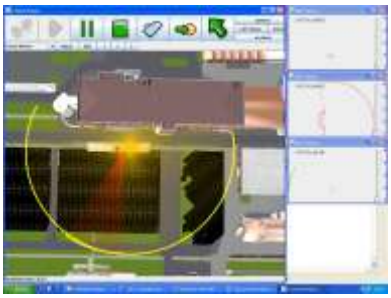
## Support system for scheduling and allocation of drivers

The management of a bus network is a complex issue. The proposed service to the urban and suburban users is subject to the satisfaction of the user expectations, the financial imperatives of the company providing the service, and the respect of the working conditions of the employees.

In this context, it was decided to develop a support system for drivers' daily service planning and its distribution during the week to get the best scheduling solutions.

## CRISTAL Project

The objective of this project is the development of the concept of an intelligent vehicle for the city of tomorrow. This is to provide to users an intelligent transportation system allowing them to move in urban and suburban environments. This transport system is based on the use of small electric vehicles, with two operating modes. A shuttle mode, where each vehicle can be driven independently of the others, and a convoy mode, in which only the first vehicle is driven, and the others are following. They are then driven by an embedded system that controls the rotation and the direction of the wheels. This project is part of the French thematic cluster "Vehicle of the Future." Lohr Industrie is the leader of this project; and the industrial and academic partners are Transitec, GEA, VULog, LORIA, and LASMEA IMARA.



As part of this project, the SeT laboratory has also developed a simulator to simulate the 3D virtual world and the physical behavior of the vehicles. This simulator will thus enable to study the robustness of the system in the case of critical scenarios such as sensor failures, driving on slippery ground, etc.

## 2.2 VIRTUAL REALITY

### Tool for the management of the site of the Eurockéennes rock festival

In the context of the Eurockéennes rock festival of Belfort, the ICAP team has developed a tool, which is offering a true virtual representation of the natural site of Malsaucy. This place hosts the music festival of Belfort every year. The developed software provides visual 3D representation and tools to assist in the management of the infrastructures, which are specific to the festival (or other events, which will take place at the same location). It is thus possible, using the 3D interface, to put all the equipment related to the event: energy networks, fencing...

Works are currently underway to simulate the crowds within the site to validate the safety and evacuation plans.



### 3D Modeling and Simulation of the Techn'Hom Site

In this project, the new locations of the Alstom and General Electric companies in the Techn'Hom technology park are modeled in 3D. An accurate representation of the environment as it is today and as that it will be tomorrow is provided. This model aims to present the new road infrastructure and property and to validate the accessibility to the site by heavy trunks using simulation.

The virtual model of the site has been reused for the technical management of some buildings. In this project, it was also connected to an information system to enhance the 3D objects with semantic information.

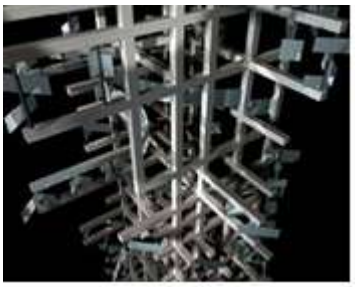
## 3D Modeling of the District of Glacis of Belfort

As part of the redevelopment of the Glacis district of Belfort, a 3D digital model of the area was conducted for the accounts of the Urban Belfort Community. This model was made from the geographic data of the city and was used to assess the impact of the demolition of some buildings.

## PANsafer Project

The main purpose of the PANsafer project is the active contribution to reducing the accidents at the train crossings. Project's activities must directly enable the improvement and development of inter-modal collaboration between road and rail. In this context, in collaboration with the laboratory of LEOST (INRETS), the SeT laboratory applies to the development of a system based on video sensors for the detection and assessment of hazardous situations around the crossing. To determine the best position for the video sensors in order to have a fully configurable test environment, a 3D simulator is being developed. The simulator will be powered by the 3D digital models of two-level crossings, identified as dangerous, and studied in this project.

## Virtual Cybernetic Lightning Tower of Nicolas Schöffer



Funded by the French Ministry of Culture, the Cybernetic Lightning Tower is developed in virtual reality. Initiated by the Gantner Space and Eléorone Schöffer, this project is based on both the virtual reality representation of the Tower and a multi-agent system that is reproduced the intelligent lightning behavior of the Tower.

## 3D Modeling of Belfort for the 700th anniversary of its Foundation

In this project, the accurate model of the city of Belfort in the year 1307 is built from historical records. Production of a DVD including a virtual visit of the city with different important points (the keep, the hall, oven, etc.) and a set of animated 3D maps explaining the evolution of the city during the time are provided.

## 3. VOXELIA COMPANY

The works of the laboratory in the context of the simulation in virtual worlds led in 2009 to create the Voxelia Company. Part of the models and the software developed by the SeT laboratory was transferred to the company.

http://www.voxelia.com

## 4. CONTACT INFORMATIONS

**Dr. Stéphane GALLAND** stephane.galland@utbm.fr

Phone: +33 (0) 384 583 418

Pr. Abderrafiaa KOUKAM abder.koukam@utbm.fr

Phone: +33 (0) 384 583 081

Web page of the multiagent team: http://www.multiagent.fr

Web page of the SeT laboratory: http://set.utbm.fr