Vision System for Virtual Agents.
Environment Model and Perception’s Architecture for Multi-Agent Based Simulation in Virtual Environments.
Application to a Pedestrian Simulation

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Context & Objectives

Definitions

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Context

Multiagent Systems and Applications Group, Systems and Transportation Laboratory (SeT).

Research Axis :
- Multiagent Systems Specification and Design.
- Heuristical approaches for distributed problem solving. Applications to Transportation’s problems.

We are integrated into labellized european projects :
- SURE-EESD : a time-oriented model for Sustainable Urban REgeneration
- AgentLink : Specification methodology and verification project (AgentLink II, MSEAS).
Objectives

Main Objective
Immerse a multiagent platform into a Virtual Environment (especially urban environment).

Constraints: Real-time, Believability

First step:
- Assure a real time perception for each agent in the simulation.
- Integrate into virtual world, the information needed by agents to develop high level behaviors: semantics.
What is an Agent?

Definition (inspired from [Ferber, 1995] et [Bouzid, 2001])

An agent is a physical or virtual entity which verifies the following properties:

- autonomy: act without human intervention and possesses resources of its own;
- communicative: communicate directly with other agents;
- responsiveness: answer to outside events;
- behavior: own one or more objectives whose behaviours tends to satisfy them;
- situation: perceive partially the environment via its sensors, eventually build a partial representation (i.e memory), and change its configuration by acting above locally via its effectors.
Virtual Environment : a short review

Informed Environment  [Farenc, Boulic and Thalmann, 1999]

- The scene is decomposed as a set of environmental entities called ENV.
- An ENV represents a surface or a volume and consists of semantical informations, a list of objects located inside the area and a list of associated actions or behaviors.

Perception is simulated by a direct extraction from environment's database.
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Virtual Urban Environment Modeling System [Donikian, 1997]
Environment is decomposed into three levels: geometrical, topological and semantical. Dedicated originally to driving simulation in urban environment and then adapt to pedestrian simulation by THOMAS [Thomas, 1999].

Perception is simulated by a direct extraction from environment's database.
Synthetic Vision : a short review

First synthetic vision system

[Renault, M-Thalmann, Thalmann, 1990]

- All objects in the frustum are projected on a 2d bitmap according to the viewer’s point of view,
- The distance from the eye to all the points of the objects are extracted from the graphical card’s Z-Buffer\(^1\),
- The objects’ identifiers are stored inside the back-buffer of the graphical card.

\(^1\) also called depth-buffer
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Artificial Fishes [Tu and Terzopoulos, 1994]

Synthetic vision system using ray casting.

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Synthetic Vision : a short review

_Noser et al._ [Noser and Thalmann, 1995]

Actors perceive their environments from small false-coloring images rendered from a point of view by the computer hardware.
Synthetic Vision: a short review

Noser et al. [Noser and Thalmann, 1995]
Actors perceive their environments from small false-coloring images rendered from a point of view by the computer hardware.

Wen et al. [Wen, Mehdi and Gough, 2002]

- Use an octree to assure the hierarchical scene decomposition: only AABB are stored.
- Reduce synthetic vision to a simple Frustum culling (Tree Traversing) and local area Z-Buffering.
Related Work : Summary

Synthetic vision needs some adaptations to respect Virtual Reality constraints :

- **Real time constraint**: Wen et al. approach :
  ⇒ **Problems**: Incompatibility with simulation involving a great number of autonomous agent.

- **Our approach is inspired from** [Wen, Mehdi and Gough, 2002] :
  Adapt the environment structures to assure fast visual perception for all agent in the simulation.
Environment Model

- Virtual Environment
- Synthetic Vision
- 3D database (scenegraph)
- Metric environment (2D)
- Topological environment
- Layer between MAS and 3D softwares
- Inside the MAS software
Metric Environment

Environmental entities classification

**Static**: immovable e.g. building, road, environment’s agent...

**Dynamic**: mobile e.g. pedestrians, vehicles...
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Vision process

- View Direction
- Point of view

AABB: Axis Aligned Bounding Box

Traverse the tree and test for clipping

Front, Overlap, Back

AABB

- Traverse the tree and test for clipping
- AABB: Axis Aligned Bounding Box
Experimental results

Mean time of Perception : \textbf{0.85 ms}

![Perception Time vs Number of Agent Graph](chart.png)
Future works

- Develop a pedestrian and/or vehicle’s simulation based on groups of agents defined from common goals and on the agents’ mutual perceptions.

- Model a environment dedicated to multiagent-based simulation in virtual environments and integrating different levels of simulation: micro, meso, macro.

**Forward objective**:
Simulate large scale Virtual Environment integrating a great number of agents (n>20 000).
Conclusion

Achieved objectives: The first step to assure the immersion of a MABS into a Virtual Environment (VE): Assure a fast visual perception for a great number of "micro-agent" in a VE.

Contributions:

▶ Synthetic Vision is compatible with real time simulation implying a great number of agents.
▶ this environment model could be see as a layer allowing to immerse a standard multiagent platform\(^2\) in a virtual world.

\(^2\) e.g. MadKit
Questions

Thanks for your attention

If you have some questions?
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