An Agent-Based Architecture for Large Virtual Landscapes

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Introduction

Context: Large reconstructed landscapes, huge DataSets (eg. Large ancient cities, territories, etc.)

- **Virtual World**
  Realism level of 3D reconstructed models is nowadays high.
  Within *Navigation*, focus is on immersivity and user satisfaction

  Major Lacks:

- **Visual Cues**
  *Content Rarefaction* (large landscapes) leads to a poor or partial comprehension of the virtual environment
  User has poor visual cues → provide interface up to explore the vr. world

- **Dynamic Elements**
  Content comprehension can be enriched with dynamic entities such as *crowd* and a *Crowd-User* interaction Model → *Agent-Based Model*
Agent-Based Crowd Model (simple)

Representation of a system composed by several actors (agents) capable of making decisions
The IteriniX Model

“Iter Ineo”
*From Latin: “To begin a Journey”*

Movement, Evolution and Information are core concepts of the architecture

- **The System**
  - Agent-Based Model using open-source framework OpenSceneGraph (*organized scene = increased efficiency*).
  - Adaptable to large DataSets and reconstructed virtual worlds
  - Portable across OS-es.
  - Dynamic Virtual World scenegraph = small or no *pre-computation* (3D geometry).

- **Goals**
  - Modular, Customizable, Adaptable, Efficient, Evolving
  - Able to react properly to *Dynamic Environments* with focus on huge *Paged DataSets*
  - Handle large crowd simulation
Agent Design

- Every agent has **rules** and **attributes** influencing its behavior (gravity, social interactions, goal seek, geo-morphology, cohesion, etc.)

- **Goal:** Simulate factors that shape human movement behavior

- **Expandable Design**

- **Internal Memory**
• Local or Remote Location
  - Contains 3D Models to represent Agents
  - Can be changed or refreshed at run-time
  - Wide support for 3D formats (3DS, OBJ, DXF, etc...)

• Linker
  Instancing: reference to the same geometry \(\rightarrow\) light memory footprint
  Different Typologies (eg. Archaeologist, Architect, etc...) with different 3D models

• Support for Level of Detail
  Every 3D typology has different LOD
  Customization of realism and quality of 3D models depending on distance
Pool – Level of Detail

5,000 Vertices  1,000 Vertices
Modeling Movement Basics

• Two main Groups
  • Independent Variables: geomorphology, gravity, area affordance, world collisions...
  • Social Variables: cohesion, avoidance, alignment, collisions, leader election, information transmission, social relationships.... → Dealing with current agent Social Radius (neighborhood)

• Manage agent collisions
  Using collision prediction algorithms
  Agent computes best solution

• How to handle all Social Variables
  Large Crowds require efficient management → Address them with Spatial Partitioning
Spatial Partitioning
Spatial Partitioning

Update Process using Bins (64x64)

- Using Bins
- No Bins

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Environment Maps

- **A Set of Layers**
  Mapping the virtual landscape:
  - Used to influence agents behavior (*magnetic net*)
  - Used to track agent paths and to evolve the routes (*pheromone trails*)
  - Adding constraints

- **Pheromone**
  Lay down *Pheromone trails* on valuable areas or good positions
  Evaporation reduces attractive strength of bad paths → network evolution

- **Affordance**
  Surface influence on movement (eg. lakes, vegetation, terrain type, etc..)
Magnetic Net

- **A set of 3D Nodes**
  - Create a *map* able to smoothly influence agents A.I. and their Routes.
  - Assign level of *importance* to resources (eg. Monuments, Buildings, etc) in terms of cultural heritage
  - Agents provide user with a *distribution feedback*

- **Nodes: Information Containers**
  Each one contains *information* of different kind within its radius (*webpage, video, audio, etc.*) split into different channels → *different streams* (eg. Architecture, History, etc.)

  They can be modified or moved *at run-time* → direct crowd reaction

  Ease of customization for didactic purposes, historical reconstruction contexts
User ↔ Crowd Interaction

- **Agents**
  They have memory about paths, effort, visited areas and information. They are collectors of information and media contents → every agent has a proper story and evolution.

- **Crowd**
  Reacts to attitude and position of the user: useful on large environments to avoid rarefaction and support the user.

- **Information Context and Guided Exploration**
  Every agent tends to collect certain kind of information, depending on its own typology (eg. Architecture, Archeology, etc...)

  User can softly link the navigation to the agent and query him for information about current direction, measurements, distances and visiting area, or modify environment (eg. Switch current building to ancient reconstruction)
Information Layer

- **Subscribers and Publishers**
  Hotspots as *Publishers* and Agents as *Subscribers*, able to supply Information to the User when interaction occurs

- **Information**
  It can be any kind of media, locally or remotely stored (eg. *webpage*)
  *Reproducing a Content* = Rendering stored Information (eg. *browser*)

- **Hotspot Node as RSS**
  Hotspots able to link to *RSS Feeds* to increase dynamic flow
Information Layer

- **Main Goal of the Layer**
  Information should be rendered into a *ease-of-use* container → good *comprehension* for the final user

- **Web-based Application approach**
  - *IteriniX* renders contents on the *Information Layer* using Chromium *Application* approach 

  - Content can be *any* generic media or even *web-based Application* (*eg., Interactive Maps*)

- **OpenSceneGraph** is also introducing *PDF* and *HTML* rendering inside the virtual world → Content Rendering can be redirected
Information Layer (screenshot)

Information Layer Video - Large Crowd Video
Conclusions

- General purpose Agent-Based Crowd Model for large dynamic landscapes
- Modular and highly customizable Design
- Support for large crowds and level of detail
- Real-Time Hotspot interaction
  Influence artificial life; Broadcast multimedia contents
- Agents collect multimedia contents
  Reproduction on user interaction; Different contexts
- Evolving paths
  Using Pheromone-Map
  Adaptable to dynamic environments
  Study emergent routes
- Agents able to guide the user
  eg. didactic purpose; Enhance Interaction
- Future Work:
  User-friendly Interface to customize parameters
  Agents able to track user actions and give suggestions
Thanks

Official IteriniX Project website:
http://phoenixbf.wikidot.com/iterinix