

#1 - Open the eyes of your Non Player Characters

White paper by Pierre Pontevia, CTO Kynogon

1. THE BEHAVIOR PARADIGM OUTLINES THE IMPORTANCE OF PERCEPTION

1.1 Decision & perception in today video games

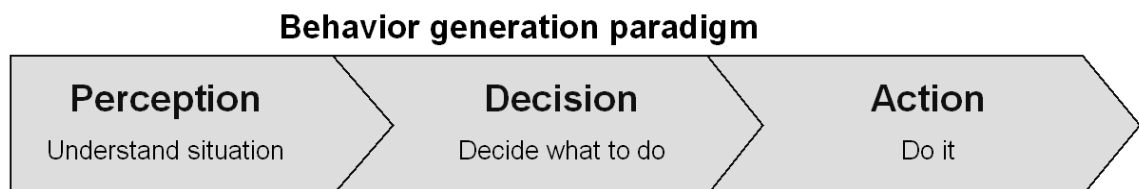
Game developers often perceive A.I. as high level decision making processes with autonomous Non Player Characters (NPC). As a consequence, they are frightened to loose control of their game: NPCs making autonomous decisions will not stay in line with their scenario. Simple decision processes like scripts or Finite State Machines are usually more relevant for games.

On the other hand, 3D perception is not considered as critical. In today's video games, NPCs have very limited 3D perception capabilities. Ray casting is very often the only way a NPC can understand its environment: NPCs are blind men with a stick.

This white paper's objective is to stress the importance of perception, its challenges and explains RenderWare A.I.'s ability to meet them.

1.2 The Behavior paradigm

Video game A.I. is about NPC behavior: pathfinding, fighting tactics, racing on a circuit, cooperation between several NPCs in a strategy game, football team behavior, etc. We propose the below paradigm to give behavior to NPCs:



- **Perception:** NPCs first need to understand world topology, identify obstacles, enemies, locate sounds, etc.
- **Decision:** Once situation is perceived, NPCs decide what to do.
- **Action:** Once decision is made, it is translated into actions.

This behavior paradigm highlights two main consequences:

- **Decision is only a part of NPC behavior.** A.I. is more than only decision making.
- **Perception is behavior foundation:** Without good perception, there is no relevant decision or action (garbage in, garbage out).

1.3 Example of 3D perception importance

3D perception is critical in many situations.

- For FPS games, decision is often trivial: get a gun, find an enemy and shoot! 3D perception is where the challenge is. To fight intelligently, a NPC needs to understand its environment to properly position itself. It will then be able to surprise enemies, hide, organize opposite flank assault, surround enemies, protect a VIP, etc. Almost all tactics are based on rich topology understanding and exploitation, for example:
 - o Identify different ways to access enemy position,
 - o Locate hiding places,
 - o Identify zones of threat (windows, doors, etc.)
 - o Take advantage of local environment properties (corners, walls, holes, etc.)
- Third person cameras also desperately need advanced perception to correctly visualize a scene. An advanced understanding of the topology will give the opportunity to position a camera in order to view the most compelling parts of the scene.

2. TODAY NPCS ARE BLIND MEN WITH A STICK

NPCs are blind men with a stick. Developers use workarounds to overcome this limit.

2.1 Ray casting

Today NPCs perception is based almost exclusively on ray casting. Not only does ray casting give NPCs a very poor understanding of their environment, but they also severely affect performances. You have to cast many rays to get an answer to such a simple question as “where should I go to hide from an enemy?” Very often developers have to limit the number of NPCs as well as the number of ray casts per NPC.

2.2 Data manually generated

In order to compensate NPCs poor 3D perception, developers also manually add topological data into the world. For example, they position hiding places, activation zones, etc. However this data does not constitute an acceptable solution to limited perception, because:

- o Manual data generation is not exhaustive ;
- o Manual data generation is time consuming ;
- o Data generated might not be compatible with game engine collision and movement models ;
- o Data tuning makes production process more complex.

2.3 Scripting

Another way to overcome poor 3D perception is to script every single event of the game. Very limited 3D perception leads to extremely detailed, case by case, decision scripting. Again scripting is not the best approach to compensate for poor perception, because:

- o It is time consuming ;
- o Interactivity means you cannot forecast everything ;
- o Scenarios become linear ;
- o It is complex to script rich behaviors including team coordination, fine positioning, etc.

3. NEXT GENERATION GAMES NEED EVEN MORE ADVANCED 3D PERCEPTION

With next generation games, workarounds to overcome poor 3D perception will not work anymore. Map sizes will probably be multiplied by a hundred, as well as number of active NPCs.

As a consequence:

- With more and more NPCs, ray casting will just become too CPU consuming ;
- Map sizes will probably make manual generation just impossible ;
- For large maps with lots of NPCs, only high level scripting will be acceptable. Very detailed scripts will turn into nightmares ;
- Large maps perception data will need streaming to optimize memory consumption.

4. RENDERWARE A.I. OPENS NON PLAYER CHARACTERS EYES

4.1 PathData

3D Perception must rely on a specific modeling of the world. It cannot come directly from rendering and physic data (ray casting). Game developers need a world modeling from a rendering perspective (polygons) or a physics perspective (collision meshes). They also need a modeling from a behavior perspective. RenderWare A.I. proposes such a modeling called the PathData. It is then used for advanced 3D perception and pathfinding.

RenderWare A.I. offers an Automatic PathData Generator tool to extract automatically this modeling. The generation process takes into account game engine specificities such as collision models and movement models. A manual edition of PathData is then possible for local customization.

PathData are compatible with streaming mechanisms in order to optimize memory consumption for large maps:

- PathData streaming manages NPCs priorities (all data do not need to be available at the same time for all NPCs) ;
- NPCs data requests are anticipated in order to avoid blocked NPCs.

Fig.1 : Pathdata Automatic generation

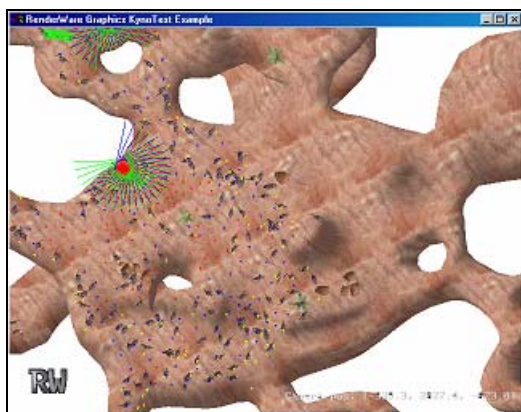
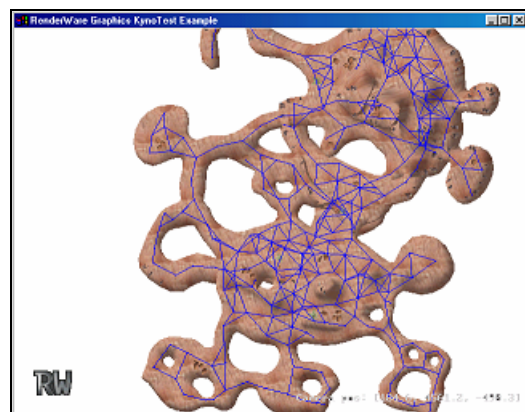


Fig. 2 : PathData Editing



4.2 Advanced 3D perception

Once PathData are available, they constitute the foundation for advanced 3D perception. NPCs need two different types of 3D perceptions:

- Advanced 3D topology dynamic analysis ;
- Accurate description of local environment.

4.2.1 Advanced 3D topology dynamic analysis

NPCs need to understand the 3D topology of their environment. RenderWare A.I. includes the 3D topology dynamic analyzer. It identifies, at runtime, places relative to a NPC, with interesting topological properties. For example:

- To kill a monster, an NPC wants to adopt a "shoot & hide" strategy. The 3D topology dynamic analyzer will identify, at runtime, all potential locations from where NPCs can easily shoot at and hide from the monster.
- 3 body guards protect a VIP. The 3D topology dynamic analyzer will identify, at runtime, all potential locations from where one can shoot at the VIP. Body guards will then position themselves in order to cover these threats.
- To attack enemies, NPCs organize an opposite flank assault. The 3D topology dynamic analyzer will identify, at runtime, the different ways to access enemies. NPCs will then know if an opposite flank assault is possible (there are at least two distant enough access ways). They will then be able to position properly for the attack.
- To properly position a camera into a room, the 3D topology dynamic analyzer is a must. Typically, you do not want the camera to look at a wall. The best method is to choose the location that maximizes the number of visible ways to access the room.

4.2.2 Accurate description of local environment

A high level understanding of the environment is key, but not sufficient. The 3D topology analysis will not always give NPCs the required perception level of detail.

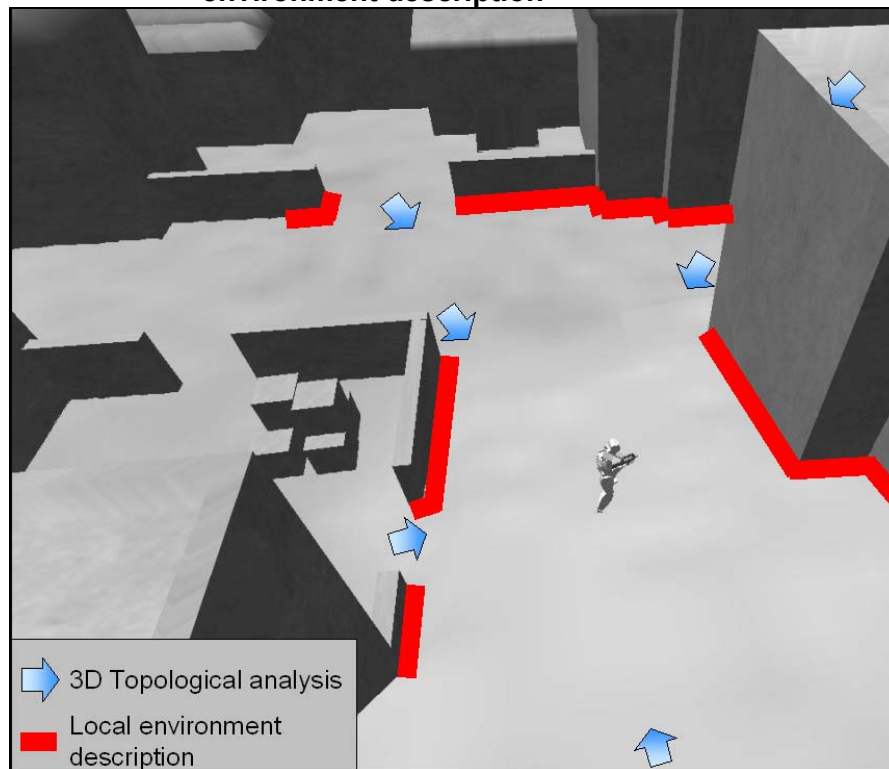
For example, a team is progressing in an urban hostile environment. The 3D topology dynamic analyzer will identify zones from where danger can come. However, to minimize exposure, team members should move along the walls from one corner to the other. The team therefore needs a local analysis to locate walls, obstacles and corners.

RenderWare A.I. will soon include new functionality specifically designed for local topology analysis. The static environment will be pre-processed via a two step analysis:

- First step: extraction of relevant local topological shapes ;
- Second step: classification of extracted shapes.

Thanks to this preliminary analysis, game developers will be able to give (at runtime) an accurate and reliable local perception without consuming CPU. They will know exactly where the surrounding walls are, where the interesting corners are, etc.

Example of perception information provided by 3D topology analysis and local environment description



RenderWare A.I.'s advanced perception algorithms transform blind NPCs into NPCs with eyes. They can throw their old stick away!