Reasoning with Ontologies in Real Time for Non-Player Character's AI in Video Games

Sylvain Lapeyrade, Christophe Rey, Bruno Bachelet and Loïc Yon

Université Clermont Auvergne, CNRS, LIMOS, Clermont-Ferrand, France

Objectives

1. **Improve** Artificial Intelligence (AI) **credibility** in games.
2. **Simplify** the AI implementation for developers and game designers.
3. **Optimise** to allow a real-time execution.

Game AI

Why video games for AI?

Video games are an ideal platform for experimentation in AI [1] :

- The virtual environment allows us to **free ourselves** from the **physical constraints** of the real world.
- **Costs** associated with development are **reduced** to software programming.
- It is **easier and quicker to model and solve** problems in a virtual environment where you can easily change the rules of the game – and therefore the world.

Context

- It is not uncommon to see **non-credible Non-Player Character (NPC)** behaviour in video games. This can result in absurd actions, such as illogical movement or inconsistent and incoherent dialogue [2].
- To **enhance the credibility** of these AIs, we propose to use **logic programming** which has proven its efficiency for several decades [3], but which is almost absent in game AI [1].

Ontological reasoning

How does logic programming works?

1. **Represent** knowledge – also called **ontologies** – e.g. facts or rules.
2. **Specify a problem declaratively** – e.g. by asking a question.
3. The **inference engine** (usually a Prolog engine) answers the problem by **reasoning logically** about ontologies.

Advantages

Why logic programming?

- Logic programming is based on **formal logic**. Unlike popular machine learning techniques, it is in line with the principles of Explainable AI **(XAI): explainability, interpretability, transparency** and **accountability**.
- **Scalability** and **maintainability** of the AI **algorithm** are simplified by the declarative aspect of logic programming and the ease of adding and removing rules.
- The use of **backward-chaining** allows one to try to prove a given goal by using rules to generate sub goals and by trying to satisfy them recursively. Among other things, it allows for efficient **planning**.

Challenges and leads

1. The approach is not **directly usable** by the developers.
   - ▷ **Need to interface** game engine (Unity) and inference engine (Prolog).
   - ▷ **Developing a library** would help to use Prolog from Unity.
2. Make the AI **more complex** while keeping its **behaviour understandable** for developers and players.
   - ▷ Using the **Belief-Desire-Intention (BDI)** [4] standard to generate action plans.
   - ▷ Using the **Well-Founded Semantic (WFS)** [5] to introduce uncertainty and negation.
3. **Scaling up** from one agent to thousands is not trivial.
   - ▷ Optimising code execution by **parallelising** and preparing it by **metaprogramming**.
   - ▷ **Determining algorithmically the resources** – i.e. the reasoning power – to be allocated to each agent.

Prototype

We have **developed a prototype** inspired by the game "Wumpus World" [3] with the **Unity game engine** and the **SWI-Prolog inference engine** in order to test the quality and efficiency of our approach.

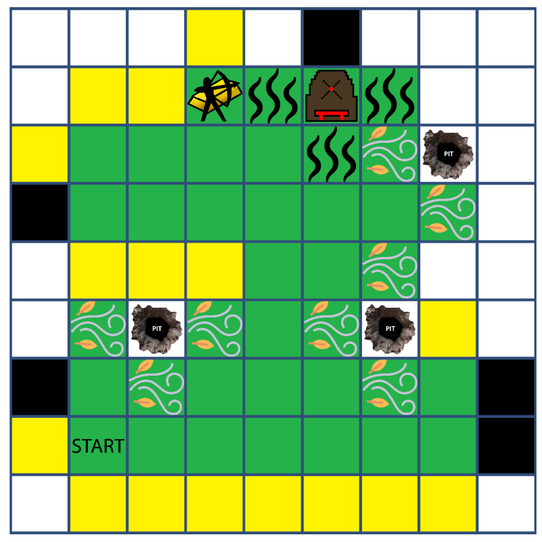

Figure 1: Snapshot of a game played by the AI on the prototype – agent view.

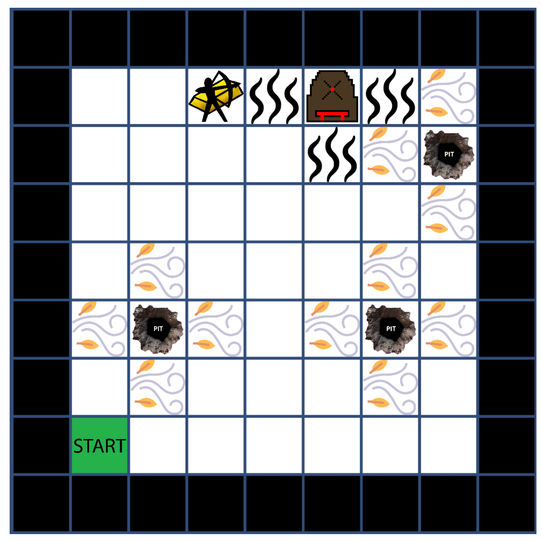

Figure 2: Snapshot of a game played by the AI on the prototype – world view.

Collaboration

Research collaboration with the independent **game development studio** Wako Factory to test the approach on a real commercial game.

Figure 3: Game project.

Why this collaboration?

1. Developing a real commercial game allows to have:
   - ▷ **Feedback** from real players and developers.
   - ▷ **Game data** for **analysis**.
2. This game would be a **showcase** for the **approach**.
   - ▷ Willingness to put the **AI at the centre** of the game.
   - ▷ The AI's **decisions** will be **visible** and **justified**.

Acknowledgements

This research was funded in equal parts by the French National Research Agency (ANR) and the European Regional Economic Development Fund (FEDER).

References

[1] Georgios N. Yannakakis and Julian Togelius. *Artificial Intelligence and Games*. Springer International Publishing : Imprint: Springer, Cham, 1st ed. 2018 edition, 2018.

[2] Ian Millington. *AI for games*. Taylor & Francis, a CRC title, part of the Taylor & Francis imprint, a member of the Taylor & Francis Group, the academic division of T&F Informa, plc, Boca Raton, third edition edition, 2019.

[3] Stuart J. Russell and Peter Norvig. *Artificial intelligence: a modern approach*. Pearson series in artificial intelligence. Pearson, Hoboken, fourth edition edition, 2021.

[4] Michael Bratman. *Intention, Plans, and Practical Reason*. Cambridge, MA: Harvard University Press, 1987. Issue: 2 Pages: 198-199.

[5] Allen Van Gelder, Kenneth A. Ross, and John S. Schlipf. The well-founded semantics for general logic programs. *Journal of the ACM*, 38(3):619–649, July 1991.

sylvain.lapeyrade@uca.fr