



Fuzzy Tactics: A scripting game that leverages fuzzy logic as an engaging game mechanic



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ARTICLE INFO

Keywords:

Video games
Fuzzy systems
Game mechanics
Scripting games

ABSTRACT

Artificial intelligence (AI) plays a major role in modern video games by making them feel both more realistic and more fun to play. Game intelligence usually works alongside the game logic, in the background, invisible to the players who enjoy the resulting character behaviors, the adaptive gameplay, and the procedurally generated content. However, artificial intelligence can also have a central role and become a major component of the overall gameplay (as for instance in the video game *Black & White*).

In this paper, we define the genre of *scripting video games* and introduce *Fuzzy Tactics*, a video game we developed that has an innovative gameplay based on fuzzy logic and uses fuzzy rules as its core game mechanic and user interaction mechanism. In *Fuzzy Tactics*, players lead their troops into battle by specifying a set of fuzzy rules that determines the battle behavior of the units. Fuzzy logic is the only mean that players have to interact with the game and to command to their troops. Thus, it becomes the main game mechanic that allows us to (i) extend the depth of the game, (ii) keep the interaction intuitive, while also (iii) increasing the replayability and the educational value of the game.

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1. Introduction

Artificial intelligence in video games aims at enhancing players' experience in various ways (Millington, 2006; Buckland, 2004); for instance, by providing intelligent behaviors for non-player characters, by implementing adaptive gameplay, by generating high-quality content (e.g. missions, meshes, textures), by controlling complex animations, by implementing tactical and strategic planning, and by supporting on-line learning. Noticeably, artificial intelligence is typically invisible to the players who become aware of its presence only when it behaves badly (as demonstrated by the huge amount of YouTube videos showing examples of bad artificial intelligence¹).

Artificial intelligence can, in few rare cases, play a more central role and become a mean to introduce *innovative* game mechanics that are built around specific techniques. For instance, the games from the *Creatures* series (Gameware Development, 1996) make the interaction with the learning mechanism of the underlying neural networks the main focus of the player. The creatures remember facts and adapt to the environment, thus looking

intelligent. The award-winning game *Black & White* (Lionhead Studios, 2001) leverages reinforcement learning to support the interaction with the player's giant pet-avatar as the main core of the gameplay. Most of the gameplay in *Black & White* (Lionhead Studios, 2001) concerns teaching what is good and what is bad to the pet, a novel mechanic enabled by the AI. In *Galactic Arms Race* (Hastings, Guha, & Stanley, 2009), the players' weapon preferences form the selection mechanism of a distributed genetic algorithm that evolves the dynamics of the particle weapons of spaceships. The players can experience the weapons' evolution based on their choices. In all these games, the underlying artificial intelligence is the main element that permeates the whole game and also the biggest selling point. The use of AI to support gameplay mechanics thus enables the exploration of new design solutions. It is however difficult to develop compelling gameplay around a specific artificial intelligence technique since it would both require a significant amount of resources for experiments and an in-depth knowledge of the technique as well as of game design; accordingly, only a few successful games based on this idea have been built so far (Gameware Development, 1996; Hastings et al., 2009; Lionhead Studios, 2001).

In this paper, we define the genre of scripting video games and introduce *Fuzzy Tactics*, a tactical role-playing game that makes the artificial intelligence, a fuzzy system in this case, the central element that supports gameplay. In *Fuzzy Tactics*, players lead their

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¹ <http://www.youtube.com/watch?v=tFxbakAamsc>.

troops into battle by specifying a set of fuzzy rules that determines the behavior of the units. In our game, the interaction with the underlying fuzzy system is the main game mechanic and thus it gives artificial intelligence a primary role by requiring players to script behaviors to be able to play. The use of fuzzy logic in the main game mechanics enables us to (i) extend the depth of the game further than would be manageable, (ii) allow more compelling gameplay to emerge, while also (iii) keeping the interaction intuitive thanks to natural language and (iv) increase the educational value of the game (which at the end can also be viewed as a joyful way to learn something about fuzzy logic).

The paper is organized as follows. In Section 2 we discuss the pros and cons of applying fuzzy logic to games. In Section 3, we briefly overview the use of fuzzy logic in commercial games and in games developed in academia; we also discuss the video games that offer mechanics related to *Fuzzy Tactics*. In Section 4, we present our approach to the use of fuzzy logic in games and show how *Fuzzy Tactics* exploits this technique to implement innovative mechanics. In Section 5, we describe the game mechanics of *Fuzzy Tactics* while in Section 6 we present examples of gameplay scenarios showing the peculiar features of our game. In Section 7, we draw some conclusions and outline directions for future research.

2. Fuzzy logic in games

Fuzzy logic has been officially introduced in game development in 1996 in the Game Developer Magazine² by O'Brien (1996) and since then it has been listed as a major technique for game artificial intelligence design by several reference sources. The major textbooks on game AI devote entire chapters to it (Bourg & Seemann, 2004; Buckland, 2004; Millington, 2006) and several introductory articles show how to apply fuzzy logic to games (e.g., McCuskey, 2000). Zarozinski (2002) stretches as far as suggesting that fuzzy logic finds its way in almost every game.

2.1. The benefits of using fuzzy logic in games

Fuzzy logic has several advantages over other artificial intelligence techniques as a mean to introduce advanced behaviors in games. Firstly, fuzzy logic needs no prerequisites apart from basic knowledge of Boolean logic and therefore it is a good candidate to add advanced AI to any game with relatively little effort. In addition, because of its linguistic nature, domain experts can specify fuzzy rules even if they have no knowledge nor understanding of the underlying technology so as to implement human experts' strategies (McCuskey, 2000). This can be very useful in sports and war simulation games. Thirdly, the input–output mappings of fuzzy rules are typically non-linear thus it is generally easy to implement complex behaviors without the need to define mathematical models that may be tedious or impossible to obtain (Gabriyel Wong, 2006); at the same time, such non-linearity is exploited to decrease the predictability of the controlled agents. Accordingly, game designers can use fuzzy logic to implement complex game intelligence without the need for a programmer to assist them. Moreover, while traditional decision making approaches can result in unnatural and unrealistic sudden switch of action policies, fuzzy logic produces smoother changes, although Millington (2006) suggests that such gradual transitions may be over-kill for most current games. Another benefit of fuzzy logic lies in its intrinsic non-sequential representation of knowledge. In fact, since fuzzy rules can be activated in any order, designers can easily add or remove rules without worrying about their activation

sequence. Fuzzy logic has also a low computational cost (Li, Musilek, & Wyard-Scott, 2004) which makes it an ideal solution due to the low resources available to game AI developers and to the real-time constraints they are often required to abide to; this benefit is one of the main reasons why fuzzy logic is favored in the gaming industry. Finally, fuzzy systems are also good candidates for in-game adaptation and learning.

To aid game developers in their implementation of a fast-performance fuzzy system, the Free Fuzzy Logic Library³ (FFLL) has been created and its use is widely encouraged in the literature (e.g., Zarozinski, 2001).

2.2. The pitfalls of fuzzy logic in games

There are relatively few drawbacks for using fuzzy logic in games. Fuzzy systems typically work better if a domain expert is available to specify what the input and output variables are, as well as to sketch the rules that represent existing relationships; if an expert is not available, it might be hard to come up with an adequate rule set and a significant amount of tuning might be needed to implement satisfactory behaviors. This may be a drawback for games based on the simulation of uncommon situations, where domain experts may not even exist (for instance, when designing the game AI for spaceship battles). In addition, if not carefully designed, the development of a fuzzy rule set may result in a large amount of (possibly redundant) rules that will be tested at each time step, dramatically increasing the computational cost. To limit this issue, several improvements have been suggested (Alexander, 2002). For instance, single-state outputs can be enforced to avoid unnecessary computations, hierarchical behaviors can be introduced to resolve groups of rules at once and parallel and independent behavior layers with different evaluation frequencies can be used.

3. Related work

Fuzzy systems have been often applied to video games to tackle several tasks e.g., to implement game intelligence (Johnson & Wiles, 2001), for graphics (Hsu, Kao, & Wu, 2009), and to support design (Lo & Wen, 2010). In this section, we overview games that are related to *Fuzzy Tactics* either for their use of fuzzy logic or for their game mechanics, in order to provide a frame of reference for the subsequent discussion.

3.1. Fuzzy logic in commercial games

Although fuzzy logic is well known in the game AI literature (Millington, 2006), it is hard to find mentions of actual commercial games that leverage fuzzy logic. This suggests two alternative conclusions: either fuzzy logic has become such a wide-spread technology that it is deemed not worth mentioning as a bullet point as compared to other more exotic techniques, or the technique, while well known in theory, is not actually used so thoroughly. Nonetheless, an older comprehensive list of games using fuzzy logic techniques can be found among the titles listed in Woodcock (2000). Unreal (Epic Games, 1998) is one of the most famous first person shooter in videogame history and has been reported to use fuzzy state machines (FuSMs) to control the behavior of enemy aliens; when published, the game was praised for its believable game intelligence (Johnson & Wiles, 2001; Woodcock, 1999). Civilization: Call to Power (Activision, 1999) (Fig. 1(a)), turn-based strategy game that is a spin-off of the well-known franchise, uses fuzzy state machines (FuSMs) to set priorities for

² Previously at <http://www.gdmag.com> now available at <http://www.gamasutra.com/topic/game-developer>.

³ <http://ffll.sourceforge.net/>.

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