Expressive AI:
Games and Artificial Intelligence

Michael Mateas
The Georgia Institute of Technology
School of Literature, Communication & Culture and College of Computing
686 Cherry Street
Atlanta, GA 30332-0165
USA
+1 404 894 2739
michaelm@cc.gatech.edu

ABSTRACT
In recent years, as dramatic increases in graphic sophistication began yielding diminishing returns, the technical focus in game design has been turning towards Artificial Intelligence (AI). While game AI might be considered a "purely technical" phenomenon not of interest to game designers and theorists, this paper argues that AI-based art and entertainment constitutes a new interdisciplinary agenda linking games studies, design practice, and technical research. I call this new interdisciplinary agenda expressive AI.

Keywords
expressive AI, game design.

INTRODUCTION
In recent years, as dramatic increases in graphic sophistication began yielding diminishing returns, the technical focus in game design has been turning towards Artificial Intelligence (AI). This change is manifest both in increasing interest in game AI at game design venues (e.g. the AI roundtable at the Game Developers Conferences), at AI research venues (e.g. the series of AAAI Symposia on AI and Interactive Entertainment [5, 15, 7]), and in game marketing that touts the sophistication of the AI rather than the graphic resolution or polygon count. While game AI might be considered a "purely technical" phenomenon not of interest to game designers and theorists, this paper argues that AI-based art and entertainment constitutes a new interdisciplinary agenda linking games studies, design practice, and technical research. I call this new interdisciplinary agenda *expressive AI*. In the context of game analysis and design, expressive AI provides a language for talking about "readable" behavior, that is, behavior that a player can read meaning into. In the context of AI research, expressive AI opens up a new technical research agenda.

Mateas. M. 2003. Expressive AI: Games and Artificial Intelligence. In *Proceedings of Level Up: Digital Games Research Conference*, Utrecht, Netherlands, Nov. 2003.

AI AND DESIGN

Language for Design and Analysis

For several years, game designers have called for a language of design [11, 2, 12], noting that designers currently lack a unified vocabulary for describing the design of existing games and thinking through the design of new games. Both design patterns, which name and describe design elements, and the closely related notion of design rules, which offer imperative advice in specific design situations, are usually articulated at a level of abstraction above the implementation details of the game, dealing purely with relationships between visual elements, game rules, and player interaction. By abstracting above implementation details, a design language can potentially be reused in many situations; in the extreme, talking and thinking about game design could in some way be lifted entirely away from game implementation.

Academic game studies is similarly developing various methods for analyzing games at an abstract content level above the implementation. Such analyses tend to draw methodologies and terminologies from various humanistic disciplines, producing a broad range of work that, for example, looks at games in terms of their use of space [10, 24], as semiotic sign systems [13], as a narrative form [24, 26], or in terms of the temporal relationships between actions and events [6]. Like the design patterns and rules of game designers, academic game studies practitioners generally seal off implementation details, treating the implementation as a black box that supports an autonomous discourse about games.

Black box analyses are certainly insightful and useful. There are abstract design patterns above the level of code, and humanistic readings of games are possible without reference to implementation. However, this paper argues that there is a place for a game language that opens up the box and considers the implementation, a "white box" language that operates at the intersection of implementation, design, and player action within the game world. This is the language of *behavior*, the language of game AI.

Game AI

The phrase "game AI" covers a diverse collection of programming and design practices including pathfinding, neural-networks, models of emotion and social situations, finite-state machines, rule systems, decision-tree learning, and many other techniques. What links these practices together under the single term "game AI" is a concern with "intelligent" behavior, that is, behavior that the player can read as being produced by an intelligence with its own desires, behavior that seems to respond to the player's actions at a level connected to the *meaning* of the player's actions. This is related to Dennett's notion of the intentional stance [4] or Newell's notion of a knowledge level [25]. Both Newell and Dennett propose that humans understand complex systems, such as other humans, by abstracting away from the mechanical details of the system (which are too complex to think about) and instead assuming that the system has goals and knowledge and will act in such a way as to accomplish its goals based on its knowledge. Game AI produces the part of a game's behavior that players can best understand by "reading" the behavior as if it results from the pursuit of goals given some knowledge. But game AI is not just about hyperrational problem solving, but also about creating a sense of aliveness, the sense that there is an entity living within the computer that has its own life independently of the player and cares about how the player's actions impact this life. For example, the enemies in a first person shooter behave in such a way that they player can interpret their behavior as a desire to kill the player while avoiding being killed. *The Sims* respond to new objects placed in the house, altering their patterns of behavior to accommodate the objects.

This effect of producing psychologically readable behavior is not limited only to explicit anthropomorphic characters within the game world, but also to intelligences operating behind the scenes. For example, the opponent in a real-time strategy game is generally not explicitly represented, but the player feels the presence of the enemy commander through the actions of the enemy troops.

Another way of abstractly characterizing game AI is to compare it to game physics. Both game AI and game physics are sources of behavior, of activity within a game. Game physics deals with the "dead" part of the game, the purely mechanical, causal processes that don't operate at the level of intentionality and thus don't respond to player activity at the level of meaning. Consider a game that implements nice physics for water. If the player throws objects in the water, they float or sink depending on their density. If a flow of water is obstructed, the water backs up or flows around the obstruction. When the player jumps into the water, they produce a satisfying splash. The water thus responds to player action – the water behaves differently depending on what the player does. But the water simulation is not part of the game AI, despite the fact that the water's response is beautiful and/or realistic and the simulation code is complex. In order to understand the water, the player doesn't have to read psychological motivations into the water. The water always behaves the same, doesn't act like it has its own goals or desires, and doesn't respond to the player's actions as if these actions had any particular meaning for it. It is possible for games to have a game physics without any game AI. In this case all the behavior of the game is a result of "non-living" processes. In *Asteroids*, for example, the asteroids move about based on their initial momentum, and break apart and change momentum based on running into each other and being hit by the player. The occasional bonus space ship that appears adds a small amount of intentional behavior (the space ship appears to evade the player), but the bulk of the game mechanic involves interacting with purely "physical" processes, meaning that the player doesn't interpret the asteroids as being alive (nor does the behavior of the asteroids support such an interpretation). Some games, such as *Space Invaders*, appear to have living beings in the game world, but don't really support a psychological read of the behavior, and thus don't have any game AI. The enemies in *Space Invaders* move purely mechanically and appear to shoot randomly – they don't require a psychological read (goals, emotions, and so forth) in order to make sense of them. From this perspective, the enemy ships in Space Invaders are really part of the physics of the game, not AI. Game AI lies at the intersection of player perception (the player is able to read part of the game behavior as alive) and the game code that supports this perception.

Analysis

To use game AI as a language for analysis requires opening up the black box of the implementation and considering the relationship between the generation of intelligent behavior, the player experience, and the cultural context of the game. In this section I'll briefly sketch what such an analysis might look like for the game *Pac-Man*.

In *Pac-Man* the player is a gobbling mouth moving through a maze filled with dots that the player must eat. A level is completed when all the dots have been eaten. The player is chased by four ghosts – if a ghost catches the player the player loses a life. Four "energy dots" temporarily reverse the chase, rendering the ghosts vulnerable and allowing the player to eat them.

A design language analysis of *Pac-Man* might focus on such elements as power-ups to temporarily create new vulnerabilities in enemies, a maze structuring spatial navigation, a difficulty curve that increases the challenge as the game continues, and level completion by gathering (eating) a collection of desired objects scattered throughout the level. A game-studies analysis of *Pac-Man* might focus on eating as an inversion of shooting (and possibly a discussion of gender roles involved in eating and shooting), or on a narrative of futile consumption (endlessly gobbling, never satisfied, destined to be killed by a ghost), or on a genre analysis, situating *Pac-Man* relative to other games that involve chasing, mazes and acquisition. But none of these analyses focus on the *behavior of the ghosts, and how this behavior impacts the player experience.*

The behavior of the ghosts is critical to understanding the game. The ghosts in fact define the primary action of the game. Without the ghosts there is no challenge in clearing a maze of pellets, and hence no game. In an interview, Toru Iwatani, *Pac-Man's* designer, clearly describes the motivation for adding ghosts to Pac-Man [16]:

> Well, there's not much entertainment in a game of eating, so we decided to create enemies to inject a little excitement and tension. The player had to fight the enemies to get the food. And each of the enemies has its own character.

The details of the ghosts' behavior is one of the primary determinants of the player experience. This behavior must challenge the player without being impossibly difficult, and be unpredictable enough to make the ghosts feel alive and responsive to the player's activity. Descriptions of *Pac-Man* tend to describe the ghosts' behavior as "chasing the player" and leave it at that. But imagine if this was literally true, that every ghost directly chased *Pac-Man*; then the gameplay would consist of the player moving around the maze with a line of ghosts constantly following behind. There would be no reason to have four ghosts as only the ghost at the front of the line would matter. The only variability in the ghost's behavior would be their speed of pursuit. If they are faster than Pac-Man, they would always eventually catch it; if they are slower, than Pac-Man could evade them indefinitely. Another interpretation of "chasing the player" is to have the ghosts work together to trap the player. Since the player is moving through a maze, there are numerous opportunities for the ghosts to corner the player by blocking all possible paths the player could take. In this case, the game would become impossibly hard, with the ghosts quickly cornering the player no matter what he or she does. Thus we can see that much of *Pac-Man's* gameplay, and thus much of the player experience, is determined by the fine details of the ghosts' behavior. In his interview, Iwatani provides a high-level description of the Pac-Man AI [16]:

> INTERVIEWER: What was the most difficult part of designing the game?
>
> IWATANI: The algorithm for the four ghosts who are dire enemies of the Pac Man – getting all the movements lined up correctly. It was tricky because the monster movements are quite complex. *This is the heart of the game.* I wanted each ghostly enemy to have a specific character and its own particular movements, so they weren't all just chasing after Pac Man in single file, which would have been tiresome and flat. One of them, the red one called Blinky, did chase directly after Pac Man. The second ghost is positioned at a point a few dots in front of Pac Man's mouth. That is his position. If Pac Man is in the centre then Monster A and Monster B are equidistant from him, but each moves independently almost "sandwiching" him. The other ghosts move more at random. That way they get closer to Pac Man in a natural way. When a human being is constantly under attack like this, he becomes discouraged.

> So we developed the wave-patterned attack – attack then disperse; as time goes by the ghosts regroup and attack again. Gradually the peaks and valleys in the curve of the wave become less pronounced so that the ghosts attack more frequently. (emphasis added)

Two important aspects to notice in the design are the variation of behavior across ghosts (different characters) and across time (different modes). The different personalities for the visually distinct ghosts opens the possibility for interesting multi-ghost behavior patterns, such as the tense but oddly exhilarating "sandwiching" behavior familiar to anyone who has spent some time playing the game, in which you move forward through the maze with two ghosts escorting you, one in front and one behind. The different behavior modes creates a sense of the ghosts having an internal life (changing moods and desires), opens up a space of richer player strategies (e.g. clearing certain difficult sections of the maze while the ghosts are in their dispersal mode), as well as providing dimensions along which the game can become more difficult besides the rather simpleminded dimension of ghost speed.

Iwatani's description in this interview, however, is far from a complete description of the ghost AI. In fact, I have been unable to find a detailed description, but rather many gamer discussions hypothesizing about the ghost AI. It is interesting that in these discussions there is agreement that that ghost AI is central to the experience of the game, but little agreement on what the ghosts' behavior actually is.

> Each ghost has its own personality: *Shadow* is the red ghost and it chases Pacman all the time, using a straight forward tracking algorithm. *Speedy* is the pink ghost. It is very fast but moves in a random manner. *Bashful* is the blue ghost: it is shy at the beginning and escapes from Pacman all the time, but if Pacman approaches him to (sic) much, then it is not shy anymore and begins to chase him (Pacman is then chased by two ghosts at the same time...). *Pokey* is the orange ghost and is slow and moves in a random manner. [14]

> Each of the four ghosts actually followed a different strategy when pursuing Pacman. One followed him, one attempted to head him off by taking alternate routes through the maze, one stayed toward the center of the maze, and the fourth ... just sort of wandered about... [9]

> By the way, did you know each of those ghosts has their own personality? Yep. Pay attention and you'll notice that the red ghost is a bit faster than the others, the blue tends to wander a little, the pink likes to set up "ambushes" for you and the orange is your basic slow plodder. The AI in this game impresses me to this day! [3]

Other than the fact that one of the ghosts (*Shadow/Blinky*) directly chases the player, there is little agreement on the degree of randomness in the other ghosts' movements, and on whether any of the ghosts actively try to ambush the player. None of these discussions mention the attach waves that Iwatani describes. And Iwatani's description is not detailed enough to resolve the dispute.

The fact that there are these multiple readings of the ghosts' behavior in fact speaks to the success of the AI design. The relatively simple algorithms of the ghost AI yields a richness and unpredictability of behavior that supports multiple interpretations, giving the ghosts an "inner life". Devising architectures and algorithms that create rich behavior supporting player projection is one of the fundamental goals of game AI.

So to really understand *Pac-Man*, to understand the player experience and the player interpretations supported by this experience, would require a detailed understanding of the ghost AI. And a detailed understanding, even if presented in natural language, would unavoidably involve descriptions of states (the different modes of the ghosts), the different strategies employed in each state for deciding where to go next, and conditions for transitioning between states. Thus the analysis would no longer be able to black box the implementation of the game, speaking only of ghosts “chasing the player”, but would open up the details of the game AI as an essential part of understanding the player experience. A full understanding of a game requires understanding the behavior of the “living” game elements – AI is the language of behavior.

In his interview, Iwatani states that designing the ghost AI was the *most difficult part of designing the game* [16]. Thus, opening up the game AI is essential not only for analysis, but as part of the language of design.

Design

AI, as a language of behavior, operates at the interface between everyday language for describing intentional behavior (e.g. “goals”, “learning”, “emotion” and so forth) and technical implementations (architecture, algorithms) that provide a specific., narrow interpretation of this everyday terminology. For example, an AI system might provide support for emotional characters, where “emotion” is implemented as a collection of numeric variables whose values rise and fall depending on action in the world, with the values at any given moment influencing how the character acts. This implementation of emotion in a game character certainly doesn’t exhaust all the rich meanings and connotations of the word “emotion” when applied in everyday life to human beings. Rather, the combination of the everyday language plus the technical implementation define a *design space*. In the case of emotional characters, for example, the everyday language of emotion (e.g. “people get mad when you steal things from them”) combined with the concrete technical implementation, provides a space of design opportunities and constraints for designing the behavior of emotional characters (e.g. “lets make a rule that increases the anger value when an object belonging to the character is taken”). The behavioral design space is structured by the architecture and algorithms of the game AI. Thus for game design languages to be able to talk about behavior requires an engagement with game AI.

Such an engagement can open up new design possibilities. For example, Andrew Stern and I have spent the last several years building *Façade*, a first-person interactive drama [21, 22, 23, 19]. Interactive drama is for some a holy grail in game design. For others, notably the camp of game studies scholars identified as ludologists (e.g. [1, 6, 8]), richly interactive stories that provide strong player agency are in principle impossible, and thus a source of much wasted effort in the games community. Our approach in *Façade* has been to explore the question of interactive story within a concrete design space that is largely defined by our AI architecture for characters and story. The details of how our architecture operationalizes the idea of dramatic beats [17], defines beat goals and conversational handlers [23], and supports natural language understanding [21], reveal interactive story opportunities as well as non-obvious constraints that force us to iterate either on the architecture or on our conception of interactive story. Much of the question of interactive story revolves around whether and how a game can provide moment-by-moment interaction that produces an immediate sense of agency while helping to structure long-term interaction into a dramatically pleasing arc (e.g. complication, crisis, climax and resolution) without diminishing the sense of agency. These are primarily questions of *behavior*, and can thus be most profitably explored within concrete design spaces defined by specific AI approaches, rather than through abstract argumentation.

GAME AI AS RESEARCH

While the technical practice of AI has an influence on the design and analysis of games, conversely, game design can have a real impact on the technical practice of AI, opening up a new research agenda that asks novel technical research questions. Game AI is an instance of expressive AI, AI research that takes AI-based art and entertainment as a first class problem [18, 19, 20]. Here I briefly summarize two goals of this research agenda in the context of games.

Game AI focuses on audience experience. Whatever the specific task of the AI, such as killing the player (e.g. monsters in a first-person shooter), defeating the player in war (e.g. strategic AI for a real-time strategy game), or learning to accomplish tasks on the player's behalf (e.g. the creature in *Black & White*), the AI is *always performing,* entertaining, frightening, and amazing the player. The AI's fundamental goal is to create an experience for the player. The measures of effectiveness used in traditional AI research, such as time to accomplish a task, number of errors, and so forth, are insufficient for guiding work in game AI. The game AI must not only accomplish tasks within the game world, but do it with style.

Game AI supports human authorship. Because game AI is a fundamental part of the player experience, the AI architecture must support game artists in expressing the behavioral potential needed for a specific design. Rather than "generic" AI that is reused over and over across games, game designers need architectural frameworks within which they can express their particular visions. Traditional AI research often attempts to find general solutions that solve a problem once and for all. But for games, it doesn't make sense to talk about solving problems "once and for all". Game designers strive to create unique designs, not repeat the same design over and over. Since game AI is a deep part of the design, novel AI architectures and approaches will need to be continuously developed within the context of specific designs and particular creative visions.

Game AI is more than an implementation issue only of interest to game designers. For game analysis, game AI is the language of intentional behavior. The gameplay can't be understood without a "white box" analysis that takes into consideration the AI architecture. For game designers, the game AI strongly influences the design space. And for AI researchers, game AI offers new high-level research goals, thus opening up new technical challenges.

REFERENCES

1. Aarseth, E. *Cybertext: Perspectives on Ergodic Literature.* Baltimore: The Johns Hopkins University Press, 1997.
2. Church, D. Formal Abstract Design Tools. Gamasutra.com. http://www.gamasutra.com/features/19990716/design_tools_01.htm. July 16, 1999.
3. Classicgaming.com. http://www.classicgaming.com/sngp/games/pac/pacman_review04.htm.
4. Dennett, D. *The Intentional Stance.* Cambridge, MA: MIT Press, 1989.
5. Dobson, W. (Ed.). *Papers from the 2000 AAAI Spring Symposium on Artificial Intelligence and Interactive Entertainment*. Menlo Park, CA: AAAI Press. 2000.

6. Eskelinen, M. 2001. Towards Computer Game Studies. In *Proceedings of SIGGRAPH 2001, Art Gallery, Art and Culture Papers*: 83-87.

7. Forbus, K. and El-Nasr, M. (Eds.). *Papers from the 2002 AAAI Spring Symposium on Artificial Intelligence and Interactive Entertainment*. Menlo Park, CA: AAAI Press. 2002.

8. Frasca, G. *Videogames of the Oppressed: Videogames as a Means for Critical Thinking and Debate*. Masters Thesis, Interactive Design and Technology Program, Georgia Institute of Technology. 2001. Available at: www.ludology.org.

9. Gamedev.net. http://www.gamedev.net/dict/term.asp?TermID=927.

10. Jenkins, H. (forthcoming). Game Design as Narrative Architecture. In N. Wardrip-Fruin and P. Harrigan. (Eds.), *First Person: New Media as Story, Performance and Game.* Cambridge MA: The MIT Press, 2003. http://web.mit.edu/21fms/www/faculty/henry3/games&narrative.html.

11. Kreimeier, B. The Case for Game Design Patterns. Gamasutra.com. http://www.gamasutra.com/features/20020313/kreimeier_01.htm. March 13, 2002.

12. Kreimeier, B. Game Design Methods: A 2003 Survey. http://www.gamasutra.com/features/20030303/kreimeier_02.shtml. March 3, 2003.

13. Kücklich, J. Perspectives of Computer Game Philology. *Games Studies: The International Journal of Computer Games Research*. Volume 3, Number 1, May 2003. http://www.gamestudies.org/0301/kucklich/

14. Kuznetz, K., Scapel, N., Mazzella, F. http://graphics.stanford.edu/courses/cs248-videogame-competition/cs248-99/pac2k/README.html.

15. Laird, J., and van Lent, M. (Eds.). *Papers from the AAAI Spring Symposium on Artificial Intelligence and Interactive Entertainment*. Menlo Park, CA: AAAI Press. 2001.

16. Lammers, Susan (ed.). *Programmers at Work: Interviews with 19 Programmers Who Shaped the Computer Industry*. Tempus Books, 1989. Interview with Iwatani is available at http://retrogamer.merseyworld.com/iwatani.htm.

17. McKee, R. *Story: Substance, Structure, Style, and the Principles of Screenwriting*. New York, NY: HarperCollins, 1997.

18. Mateas, M. Expressive AI: A Semiotic Analysis of Machinic Affordances. Proceedings of the 3rd Conference on Computational Semiotics and New Media, University of Teesside, UK. 2003.

19. Mateas, M. Interactive Drama, Art and Artificial Intelligence. Ph.D. Dissertation, Computer Science Department, Carnegie Mellon University. CMU-CS-02-206. 2002. Available at www.cs.cmu.edu/~michaelm.

20. Mateas, M. Expressive AI: A hybrid art and science practice**.** *Leonardo: Journal of the International Society for Arts, Sciences, and Technology* 34 (2), 147-153. 2001.

21. Mateas, M. & Stern, A. Integrating Plot, Character and Natural Language Processing in the Interactive Drama Facade. In Göbel, S., Braun, N., Spierling, ,U., Dechau, J., and Diener, H. (Eds.) *Proceedings of Technologies in Interactive Digital Storytelling and Entertainment*. ZDGV, Darmstadt, Germany, 2003.

22. Mateas, M. & Stern, A. Facade, an Experiment in Building a Fully-Realized Interactive Drama. In *Proceedings of the Game Developers Conference*, San Jose, CA. 2003.

23. Mateas, M. & Stern, A. A Behavior Language for Story-based Believable Agents. *IEEE Intelligent Systems*, Vol. 17, No. 4. 2002.

24. Murray, J. *Hamlet on the Holodeck*. Cambridge, MA: MIT Press, 1998.

25. Newell, A. The Knowledge Level. *Artificial Intelligence* 18: 87-127. 1982.

26. Ryan, M. Beyond Myth and Metaphor: The Case of Narrative In Digital Media. *Games Studies: The International Journal of Computer Games Research*. Volume 1, Issue 1, July 2001. http://www.gamestudies.org/0101/ryan/.