Extracting AI Technologies From Past Digital Games: By Using MCS-AI Dynamic Cooperative Model

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Abstract

Only a few technical documents regarding Artificial Intelligence (AI) in digital games have been published in Japan to date. Therefore, the history of game AI has been reconstructed from a limited number of published technical documents. To uncover this history in more depth, we must use a system to extract AI technologies from historical games. We propose a technique using an MCS-AI dynamic cooperative model to extract AI technologies. This paper demonstrates that MCS- AI dynamic cooperative models used to construct a modern game AI fundamental system. By applying the model to games from the 80's and 90's, they can be broken down into a variety of technical components that can be categorized in MCS- AI dynamic cooperative model as meta-AI, character AI, and spatial AI.

Proposed Method

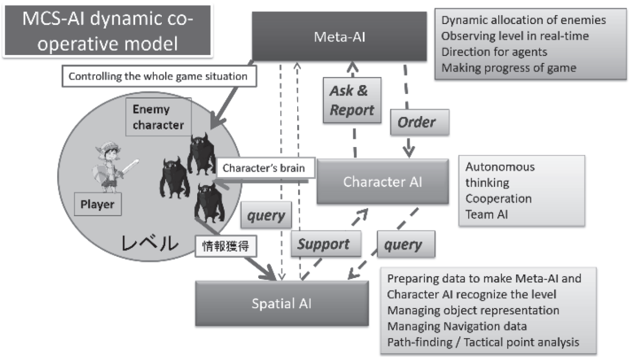

Figure 1. MCS-AI dynamic cooperative model (Miyake, 2020b)

The MCS-AI dynamic cooperative model is the combined model of how meta-AI, character AI, and spatial AI cooperate within a single digital game (Miyake 2020a, 2021). Meta-AI functions to control the game itself, character AI is the brain of non-player characters, and spatial AI recognizes the spatial feature of an environment in the game (Figure.1). Originally, this model was designed to construct the fundamental system of the game AI of a digital game and conduct AI functions requested from the game design. However, this model is also useful in extracting AI technologies from video games of the past.

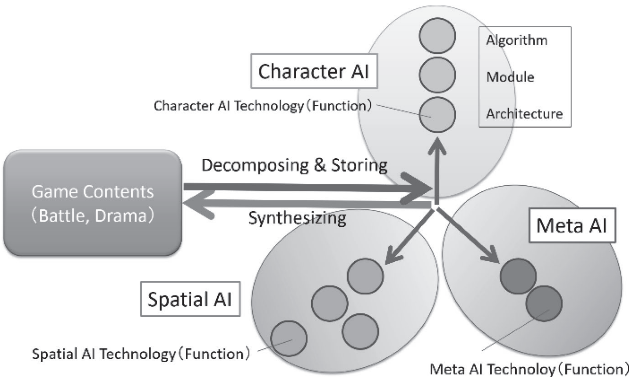

Figure 2. A diagram of decomposing by MCS-AI (Miyake and Toriumi, 2021)

By analyzing any past game through using this model, the game can be categorized into the following AI technologies: meta-AI, character AI, and spatial AI. Vice versa, by adding the AI technologies of meta-AI, character AI, and spatial AI, a new game system is generated. The design within an old game can be categorized into three kinds of AIs, and their AI technologies are stored as functions of Meta-AI, character AI, and spatial AI. On the contrary, a new game design can be composed from the three kinds of AI with new AI components (Figure.2). A case of this method will be shown through using "PACMAN" (1980, BANDAI NAMCO Entertainment Inc.).

Decomposing PAC-MAN with the MCS-AI Dynamic Cooperative Model

The specification document of PAC-MAN was published in 2019 (Iwatani, Miyake and Takahashi, 2019). By utilizing this document, various techniques have been extracted and are represented as functions of meta-AI, character AI, and spatial AI (Table 1). Initially, these technologies were not referred to as AI, but with the MCS-AI dynamic cooperative model, they can be recognized as AI technologies and explained below.

Table 1. Extracted AI features of PAC-MAN

AI Category	Specifics
Meta AI	Two modes of enemies' wave attack
Character AI	Enemies' characteristic behaviors and indirect cooperation
Meta-AI	Spawning time control
Meta-AI	Speed control of monsters within each level

Two Modes of Enemies' Wave Attack

A "wave" represents a synchronized attack by enemy characters. In PAC-MAN, there are two modes of enemy behaviors, including the surrounding mode and dispersion mode. During the surrounding mode, four ghosts run around the player character, but in the dispersion mode, the ghosts disperse to the four corners of the stage (Figure 3).

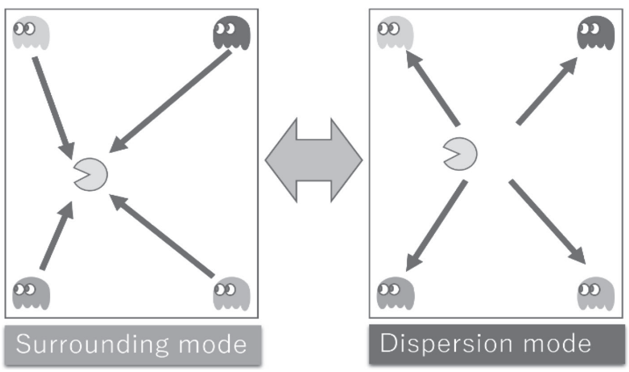

Figure 3. Surrounding mode and dispersion mode

The two modes are repeated in a predetermined time table. For example, the surrounding mode lasts for 20 seconds, and the dispersion mode lasts for seven seconds. PAC-MAN prepares three types of timetables (Figure 4).

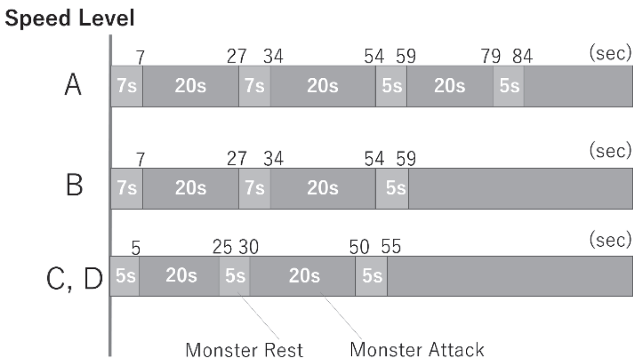

Figure 4. Time table for enemy characters' tactics (Iwatani, Miyake and Takahashi, 2019)

The group control of the four ghosts with the two modes can be categorized as a function of meta-AI, and this technique can be widely applied to various types of video games. For example, it can easily be applied to stages in 3D games that feature spatial pathfinding AI. Furthermore, the time table can easily be rewritten to fit each game, or can be changed to a more dynamic system in which the meta-AI determines the timing to change modes by observing the current situation.

Enemies' Characteristic Behaviors and Indirect Cooperation

There are four types of enemy ghosts in PAC-MAN who all have individual characteristics. Their behaviors are also different in surrounding mode and dispersion mode (Figure 5). For example, Blinky (red ghost) goes straight for Pac-man in surround mode, however, it heads to the upper right corner of the stage and moves around the area in dispersion mode. On the other hand, Pinky (pink ghost) positions itself three cells in front of Pac-man's position in the surrounding mode, and goes to the upper left corner of the stage and moves around in dispersion mode. Inky (cyan ghost) positions itself symmetrically to Blinky's position around Pac-man's position in surrounding mode, while heading to the lower right corner of the stage and moving around it in dispersion mode. Clyde (orange ghost) has the same behavior as Blinky within 130 dots from Pac-man. It moves randomly out of the 130 dots in surrounding mode and goes to the lower-left corner of the stage while moving around it in dispersion mode.

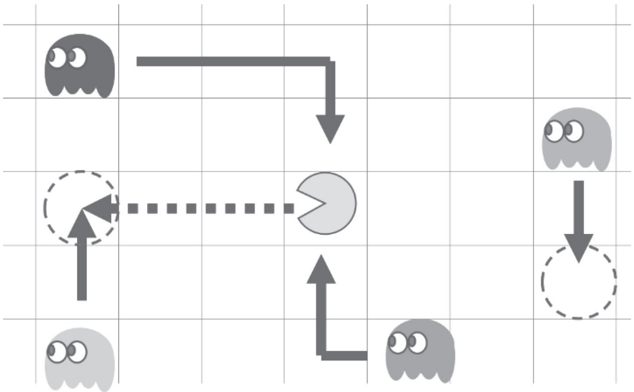

Figure 5. Surrounding mode

These different behaviors constitute indirect cooperation. They do not have any direct communication with each other, but their different behaviors' policies make up for a positional cooperation to surround the player, and the iteration of the two modes provides rhythm in the game play.

This technique can be considered as a form of character AI technology, and can be applied to other games in which multiple enemies appear simultaneously. The cooperation of enemy agents is a difficult problem in general because it must be done in complex terrains within a game. The methods of pathfinding and terrain analysis of games in the 80's are not popular technologies in the game industry. However, spatial AI was developed after the year 2000, allowing enemies to find a path and reach the best position. Therefore, it can be said that the cooperative enemy movements in PAC-MAN is a form of spatial AI that can be applied to any 3D game that features complex stages and terrains.

Spawning Time Control

Spawning occurs when a created character appears in a game. In many games, the spawning timing and positions of the characters are predetermined, but in PAC-MAN, the timing of when characters are spawn changes dynamically according to the number of food items PAC-MAN eats. There are three patterns of spawning in PAC-MAN (Figure 6), and one of them is selected for each stage.

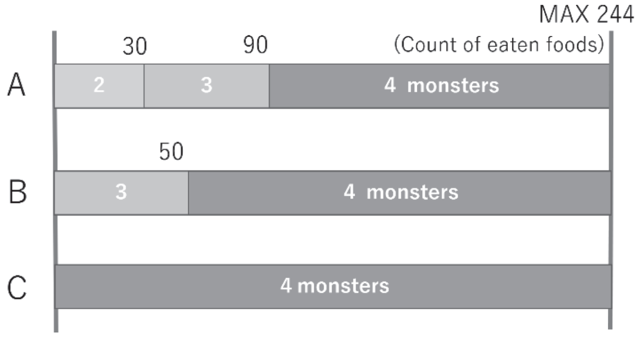

Figure 6. Number of Monsters to be spawn (Iwatani, Miyake and Takahashi, 2019)

In pattern A, only two ghosts appear in the beginning of the game, but after the player character eats 30 food items, another ghost will appear. Finally, after 90 foods are consumed, the fourth ghost is spawn. In pattern B, only three ghosts appear in the beginning of the game, but after a player character consumes 50 foods, the fourth ghost will appear. In pattern C, all ghosts are spawn at the beginning of the game.

This technology can be considered as Meta-AI because controlling the number of enemies is a key role in Meta-AI. Meta-AI adds excitement to makes exciting situation in a game by spawning enemies while it keeps observing the player character's current status (Booth, 2009, Brewer, 2013). Historically speaking, PAC-MAN's spawning system is the first instance of Meta-AI control in a video game stage, and this technique can be implemented in any game that has multiple enemies.

Speed Control of Ghosts in Each Level

The speed of ghosts and the player character is not constant and will change accordingly with the state of the player character. This state is defined by whether it eats a power food or not, while the state of a ghost is defined by whether it is escaping from a player character or not. All the speeds of the ghosts in different statuses and the player character are defined in the speed table (Figure 7). The table includes four patterns (A, B, C, D) and each pattern determines the game difficulty.

This technique can be categorized as Meta-AI because it not only controls enemies but also the entire game state. The speed table is very useful technique such that Meta-AI can change a difficulty by setting a pattern.

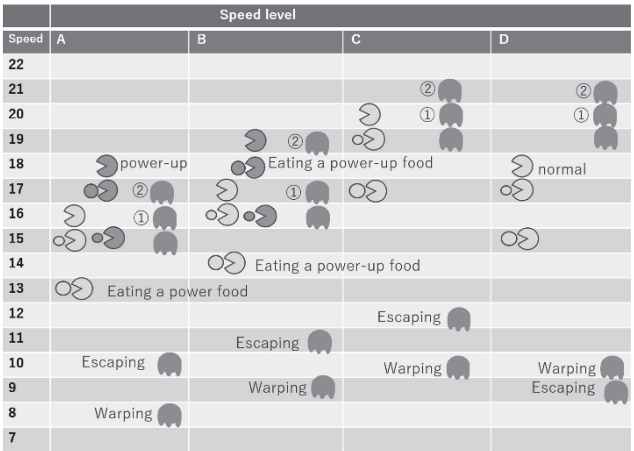

Figure 7. Speed table of PAC-MAN
(Iwatani, Miyake and Takahashi, 2019)

Synthesizing Process

As described above, by using the MCS-AI dynamic cooperative model, PAC-MAN can be analyzed into meta-AI, character AI, and spatial AI. The three techniques are stored as meta-AI, and one technique is stored as character AI.

Vice versa, by adding a new AI technology to the model, a new game design can be generated (Figure 8). An analysis of PAC-MAN showed that it doesn't have spatial AI. In order to extend PAC-MAN's game design, pathfinding algorithm and TPS (tactical point system) (Jack, Vehkala, 2013) are effective.

Pathfinding can calculate the shortest path to the goal, and therefore the ghost's path can be improved by applying it. However, pathfinding can be used to predict a user's path as well. For example, there are many power-up foods in the stage and the player character will go towards one of them. Meta-AI can estimate the next power-up food which the player wants to get and predict the path that the player character will take. This path is called the *golden path*.

Furthermore, by using TPS, a technique to find the best position to move to, ghosts can find the correct route in order to defeat the player. The algorithm is to put many points on the stage and select appropriate points by evaluating them from terrain and environment information. By using TPS, the meta-AI can find the appropriate positions to wait for the player character. The Meta-AI orders some ghosts to go to the positions that have been determined by the TPS in order to surround the player/character (Figure 9). Thus, the ghosts are positioned in a clever way.

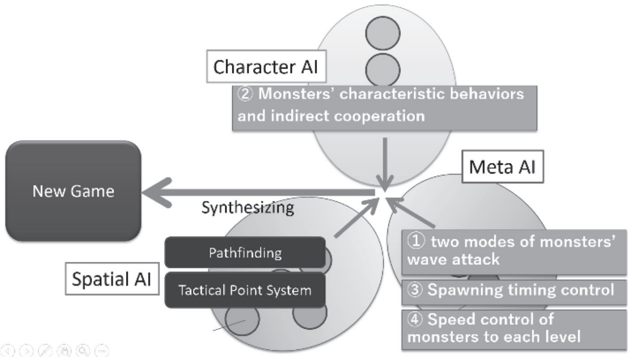

Figure 8. Synthesizing process

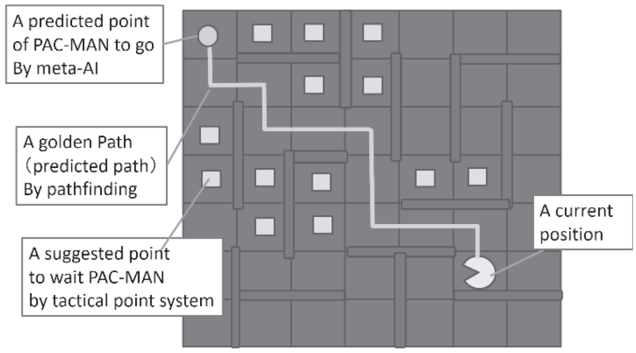

Figure 9. A new game design

Summary

This paper demonstrated a method to extract AI technologies from a digital game through the MCS-AI dynamic cooperative model and to synthesize a new game design by adding new AI technologies. As an example, PAC-MAN was analyzed into AI technologies, and a new game system was synthesized from the AI technologies of PAC-MAN with new AI technologies.

AI technologies in games can be extracted and stored by applying this method. In the future, by analyzing many games from the past, various AI technologies can be stored as a MCS-AI dynamic cooperative model. Vice versa, many new game designs can be synthesized by combining various AI technologies.

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