Game Theory and Game Mechanics Design

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Abstract. This paper focuses on the significance of game balance in games and explores the application of game theory concepts for designing and analyzing balanced gameplay. When analyzing instances of games, the paper initially presents the renowned prisoner's dilemma, a prominent problem in game theory, and delves into diverse strategies along with their corresponding advantages, thereby enabling readers to appreciate the captivating essence of game theory. After that, the paper respectively mentions two individual cases from two different forms of games. The well-known game Rock-Paper-Scissors is a simple strategy game. FPS (First Person Shooter) game is a sort of video game that is a complex strategy game. In analyzing this type of game, the paper draws images to show the imbalance in the game. In the end, the article puts forward the prospect that game theory can contribute to game design. The approach adopted in this study integrates existing research in game theory with practical insights from game design, without delving into extensive theoretical derivations or complex formulas.

1 Introduction

Games are already like literature or anything else that's becoming a fundamental part of life. When playing the games, the most essential thing is the balance. The concept of balance is not novel. In a two-player competitive game, game balance refers to a scenario where both players have an equal 50% chance of winning in multiple rounds if they possess the same skill level and comprehensive understanding of the game rules [1]. However, when it comes to confrontations involving “n” individuals or teams, the situation becomes slightly more intricate. Nevertheless, from a victory standpoint, each person or team should ideally have a win rate of “1/n.” Balance serves as a parameter for evaluating whether the game can achieve its intended design win rate. At this point, it can think of game theory. The primary objective in game theory is to analyze the solution of a game, commonly referred to as the strategy of game equilibrium. A "balanced" game implies that when the game reaches equilibrium, the players' payoffs should be equal. Regardless of whether the payoff is positive, negative, or zero, equality signifies "balance" [2]. Therefore, this paper is going to talk about the application of game theory in the strategy design of games

2 Analysis

2.1 Introduction of game theory

There is a famous problem of game theory called the Prisoner's dilemma. This is about the cooperation and betrayal of two prisoners. Each prisoner is given the choice to either remain silent or betray the other. If they choose silence, they will receive a sentence of 1 year; if they betray each other, the sentence is reduced to 0 years; however, if both prisoners remain silent, they will be sentenced to 3 years. For this game, assume that there are two people, A and B, who each have two choices, cooperate or betray. A supposed to choose between the two that give me more benefit, and then A is going to have to think about which of these two choices A’s going to make, and A’s going to have to weigh. At the same time, how much A benefit depends not only on own choice but also on the choice of the other person, so each person has two choices, 2*2. There are four situations, and then in each of these four situations. As shown in table 1, it can evaluate A’s benefit and the other person's benefit.

Table 1. Mutual benefit assessment form (uncompleted)

B A	Silent	Betray
Silent		
Betray		

For convenience, denoting it as (0,0), where the first element represents A's payoff and the second element represents B's payoff. Moreover, cooperation is often characterized by mutual benefits; thus, considering the outcomes to be (1,1). Firstly, since betrayal implies

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profitability, the gains from a successful act of betrayal are often greater than those from cooperation. Simultaneously, the losses incurred by the betrayed party are typically more severe compared to mutual betrayals which people perceive as -1. Henceforth, a table can be constructed in this manner, as shown in table 2.

Table 2. Mutual benefit assessment form (completed)

B A	Silent	Betray
Silent	(1, 1)	(-1, 2)
Betray	(2, -1)	(0, 0)

In this scenario, assuming effective communication between the two individuals, remaining silent becomes the optimal solution for them. If Prisoner A chooses silence, he faces the possibility of being sentenced to either 1 or 3 years; on the other hand, if he opts for betrayal, he may receive a sentence of either 0 or 2 years. Therefore, regardless of Prisoner B's choice, betrayal remains the best strategy for Prisoner A in what is famously known as the Prisoner's dilemma.

The application of game theory provides a robust framework for analyzing optimal strategies in both two-player and multiplayer games. Simultaneously, it enables the development of more equitable game mechanics.

There are many types of games in the world, and their rules are different. Games are activities of a recreational nature that usually involve a set of rules and objectives, as well as some degree of interaction and competition. Games can be played in a variety of scenarios, such as video games, board games, and sports.

2.2 Simple strategy games

The most common games played by children are often the simplest ones. These games can be played anytime and anywhere. From an early age, it learned that in a game against others, if the rules or participants are not balanced, the game will lose its meaning. For instance, in the famous game rock-paper-scissor, imagine a scenario where scissors become an invincible tool capable of defeating all defenses. In such a case, all players inevitably choose scissors. Consequently, no one has a chance to win and the unpredictability of the game at this point emphasizes the joy it brings to people. The core idea of game theory is the Nash equilibrium. If each player in a policy configuration cannot obtain a higher return by changing his or her strategy alone, this policy configuration is called a Nash equilibrium. However, there is no real Nash equilibrium in the rock-paper-scissor game, because it is a symmetrical game where all players have the same function. Games with mutual restraint of functions like rock-paper-scissor form a triangle pattern. Therefore, the
rock-paper-scissor mode eliminates the Nash equilibrium. The probability of rock, paper, scissors is 33.3%.

2.3 Complex strategy games

The rock-paper-scissor is one of the simplest games, but for most games that require strategy, the problem gets more complicated because different outcomes have different payoffs.

A video game is a form of interactive entertainment that involves player engagement with a virtual world or simulated environment. It typically includes elements such as graphics, sound effects, and gameplay mechanics to provide an immersive experience. There is a classic type of video game, which is a good example to explain balance in complex strategy games. That is FPS (First-person Shooting game). As the name suggests, a first-person shooting game involves shooting from the player's subjective perspective. Unlike other games where players control virtual characters on the screen, in this genre they experience the immersive visual impact of the game, thereby significantly enhancing their agency and sense of realism.

As mentioned in the introduction, balance is the foundation of adversarial games. In the perspective of game theory. A completer game should encompass five key elements: firstly, the game participants; secondly, the game information, which refers to the strategic decision-making information available to players; thirdly, the set of all possible behaviors or strategies that can be chosen in the game; fourthly, the order of play, indicating the priority for participants to make strategic choices; and finally, the payoff structure for each party involved in terms of gains and losses after making decisions [3]. In FPS games, the player assumes the role of a participant; Players acquire game information through learning the rules and battlefield intelligence; The choices made by players represent their behaviors and strategies in game theory; The sequence of players' actions falls under the concept of game order; Within game theory, the achievement of the game goal by a player is contingent upon their chosen strategy, resulting in a payoff. The traditional two-team PFS game aims to ensure that the game equilibrium represents a zero-sum outcome, where winners and losers are determined through level design, gameplay design, and matching systems. In other words, there must be a clear distinction between a winner and a loser. However, when the game reaches a state of equilibrium, all rational players are inclined to maintain the status quo rather than alter their actions, as any changes would result in a disadvantageous outcome. Therefore, how does the game progress? It's all about game mechanics. Mechanisms such as victory conditions force the player out of the game equilibrium.

In game design, game designers need to consider the game mechanics that will facilitate the game without creating an imbalance. There are many kinds of imbalances in FPS games. One of the most common imbalances is imbalance caused by different incomes. For example, a level designer always need to think about the placement of cover in the scene; Cover is the gameplay element that makes the most immediate difference to the player's revenue.

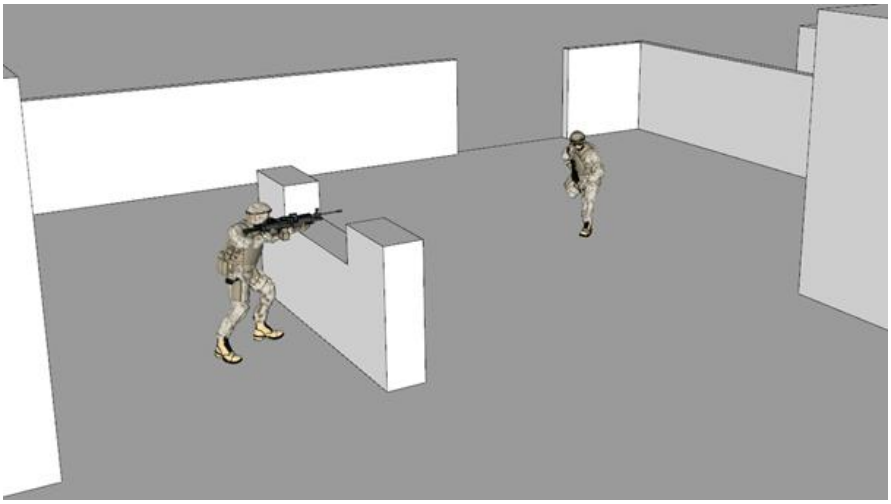

Fig. 1. Unbalanced area design (Photo/Picture credit: Original)

In the situation shown in figure 1, the player standing behind the bunker has a clear advantage. In this situation, the one who can seize the position behind the bunker first will have a greater probability of killing the enemy player, which is a typical unbalanced design. If you want to balance this scene, there are many ways. The simplest is to place an identical bunker in a symmetrical position within the space, as long as the player enters the bunker for the same amount of time, the spatial symmetry must be balanced [4]. But in the design of most games, such a crude approach is often not adopted. This is not true, and easily causes the player to be confused about its position [5].

The role of the information gap is also significant in achieving a well-balanced design. A common manifestation of the information gap in life can be likened to single-sided glass. In FPS games, the most common design imbalance caused by inadequate information (in this case mainly parallax) is channel corners.

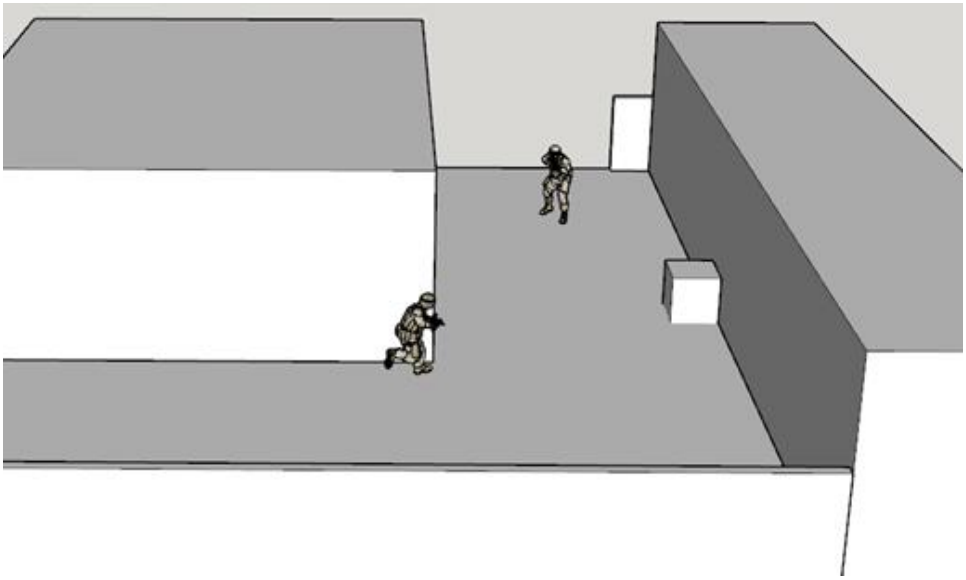

Fig. 2. Unbalanced channel Angle caused by parallax (Photo/Picture credit: Original)

Assuming that Player A must pass the corner and that the enemy on the right also knows this information, Player A's perspective will be as figure 2 when Player A's path is narrow.

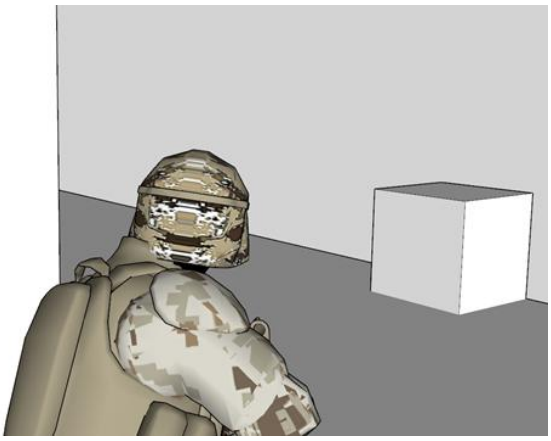

Fig. 3. Unbalanced channel angles caused by parallax (Photo/Picture credit: Original)

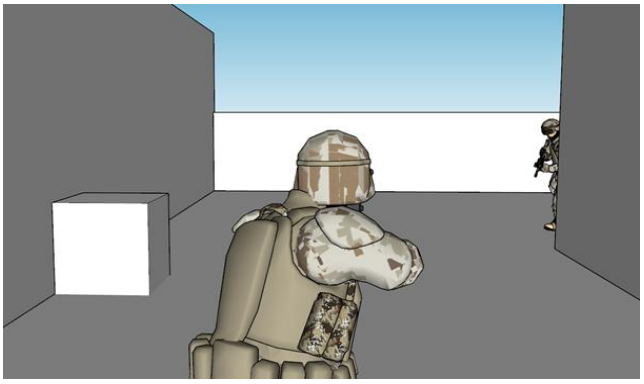

Fig. 4. Unbalanced channel angles caused by parallax (Photo/Picture credit: Original)

In other words, before Player A turns to see Player B, Player B has already seen Player A's exposed position. As shown in figure 3 and figure 4, this situation often exists in real combat, resulting in the Close Quarter Battle corner strategy, that is, when passing the channel corner, it must be close to the outside of the corner, and put away weapons to reduce the impact of parallax [6].

Most FPS battle maps are unbalanced [7]. However, it is important to be clear that all levels are designed to avoid absolute imbalance. As mentioned in the rock-paper-scissors example above, scissors can always win, if the players are rational and can choose scissors, then the game becomes a never-ending draw. In game theory, this situation is called a superior or inferior solution [8,9]. To experience a rich variety of games, that can be carried out normally, so that the game in addition to competing marksmanship, there is a certain strategic (branching, specific weapon advantage points, standing positions, etc.), local relatively unbalanced design necessary. Overall balance is also necessary to reduce the map's dependence on game mechanics [10].

3 Conclusion

The level design of a designer's ideas and abilities is most prominently manifested through a combination of partial unbalance and overall balance. Within the intricate 3D space, the gameplay area is meticulously planned, incorporating key elements that seamlessly integrate with the game mechanics. Ultimately, creating an immersive experience for players within an ostensibly raw environment stands as one of the paramount objectives for a level designer in such games.

For a complete game mode gameplay, levels alone cannot guarantee balance. External mechanisms, such as matching, Ban&Pick, and internal mechanisms, such as random position resurrection and half side change, jointly build a complex dynamic incomplete information game system that does not let any party dominate. The game pushes the player away from the game balance through the victory condition so that the participating players can build their information greater than the strategy is greater than the income cycle according to their understanding of the game, and constantly battle with the opponent players according to the dynamic scene.

In the practical design application, not only the balance of scenes and levels should be judged qualitatively, but also the quantitative analysis and practical statistics of the balance data information related to the model through user research, online testing, and other methods. With the development of AI technology in recent years, the use of machine learning agents to simulate the behavior of human players, and the solution of discovering the problems of maps and modes that are not online in advance has also been applied in many games.

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