A Novel Approach to Dynamic Difficulty Adjustment (DDA) in Battle Royale Games (BRG)

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Abstract **– Dynamic Difficulty Adjustment (DDA) is a customizable solution for game players to adjust the level of difficulty in computer games to the skills of the player by automatically modifying the features, dimensions, and scenarios of the game. This paper explores the different approaches to address DDA to provide a flexible, dynamic and interactive gaming experience for the player of Battle Royale Games (BRG). An automated difficulty selection mechanism is proposed for addressing the challenges faced by the players of PUBG, Call of duty and Garena free fire games.**

Index Terms - Dynamic Difficulty Adjustment (DDA), Computer games, Artificial intelligence, Battle Royale Games (BRG).

I. INTRODUCTION

The boost in playing games was of course due to the global outbreak of Covid-19 pandemic. The growth in consumption of digital devices and penetration of internet made online games a mainstream entertainment option resulting in the growth of gaming industry. The development of technological advances made video games prominent in the gaming genre bringing a new level of entertainment through enhancements, upgrades and optimizations. There are professional players and casual players playing for sport or fun, the ultimate objective is to win. Video games are largely available in the market and are one of the most complex programs in the world which are extremely hard to develop a game and maintain. The enthusiasm, goals and interest of the game players may be different leading to the design of games for entertainment, education, and other purposes. Gameplay is the interaction between the player, rules, and objects in the game. Goals, rules, challenges, and objects are the elements of game design that produces desirable interactions. Action games, role-playing games, puzzle games, strategy games, simulation games, word games and Adventure games are some of them.

Players begin games at different skill levels developing their skill at different rates. Difficulty is a crucial factor in game and increases with progress in game level. The levels will help the players to keep the spirit and continue playing. But at the same time, due to the different levels even the best-designed games may seem to be uninterestingly easy for some players and very frustratingly difficult for others. This is because, as the level increases, there are more exciting activities to be unlocked. Every player wants to be in higher level and unlock all the activities in higher levels. So, if players are not able to achieve that and are facing continuous failures, they will be frustrated. Game will be boring if the game is too easy to unlock the higher level. In both situations, there is a chance that player will stop playing games. The game difficulty increases regularly as the game progresses in a smooth linear fashion or as steps (levels). The scores of the players should exhibit a steady improvement to make the player interested. The beginners, intermediaries and experienced players need to make progress in their scores despite the difficulties faced. The factors that increase the level of difficulty can be modulated at the beginning of the game by choosing a difficulty level. This also can annoy the players. Great gaming experience can be achieved, enjoyed and improved by upgrading the skills and accessories.

The game designers infuse fun with curiosity, fantasy, control and challenge to be kept in balance for the player to be entertained. The game difficulty and player skill must match making the challenge parameter difficult to control. Taking break between challenges will prevent overwhelming the player and create an enthralling and delightful experience.

Even though the game and the difficulty levels are same, players may feel different engaging experience because of the large diversity among the players with different learning speed, skill set, and experiences. Dynamic Difficulty Adjustment (DDA) is one of the solutions for this problem where the game alters itself during the play, in response to player performance. DDA adjusts the game's level of difficulty to easy or hard by analyzing the performance of the player. One of the most common methods to implement DDA is through heuristic prediction and intervention, adjusting game difficulty by

analyzing the player's skill. It alters the level of challenge based on the real time feedback from the player. The flow of the game also depicts an optimal balance between anxiety and boredom. The flow experience of games is achieved by clearing the goals at different levels. The DDA system guides the player into the flow zone by tracking and adapting to the player's skill. DDA is an Artificial Intelligence (AI) based system that changes the attributes within the game at run time thereby increasing the confidence of the player to beat the game when presented with a hard challenge.

A critical challenge for tailoring the difficulty level in real time (dynamically) is to make the change at times when the player is not aware. There is difficulty in understanding the player's performance at the beginning of the game. The tutorials for playing games (playable tutorials) give a notion of the player performance. Balance with reliable and consistent feedback is critical to gaming systems.

The game designer does not need to pre-determine one specific difficulty curve but can effectively provide a range of possible difficulties which are dynamically selected for each individual player based on their experience of the game. It allows the player to select easy, medium or hard mode of difficulty. Measuring the player performance and adjusting the challenge accordingly is involved in DDA. The main cost factor in the design and maintenance of games is balancing the game and the elements in it to create interest in the player.

Variables to evaluate the player performance correspond to game rules, win or loss conditions and skill of the player. Variables in games also indicate the current state of the player and his learning process. The number of variables chosen depends on the type and complexity of the game. Considering a higher number of variables will give a precise adjustment in difficulty. The DDA system keeps track of the game variables by overwriting the variable value by triggering an event or by permanent tracking. The event triggered parameters change on fulfilling a condition or performing an action. Variables that are always in the game are permanently tracked. In a computer game the variables of life and death constantly change. The score of the game is a variable with the number of points collected. The time spend to play a game is also a variable that depends on the interest and skill of the player.

II. BATTLE ROYALE GAMES

A Battle Royale is a popular online multiplayer video game genre involving dozens to hundreds players where players battle it out until only one player or team remains. Players can start from the basics, then increase their levels and rank according to their game play. Players are given a space to defeat other players and survive to the end. The winner will be the last player who is alive. Players will get points according to their survival time, number of enemies defeated and for some other factors. Points gained from previous games will be deducted from the total points if they cannot survive for a long time in the current game.

The multiplayer Battle Royale Games (BRG) Free fire, PUBG, Call of duty are considered in this paper. These games are getting a very huge hype as players interact with other real time players with frequent new features and updates making them more attractive. These games are with real time players making it hard to predict the game play of players and the difficulty in each game. The difficulty and frustration of players of BRG are discussed in this paper and a proposal that how we can solve these problems by implementing DDA in real time player games.

The Battle Royale genre in gaming was started by PUBG (Player Unknown's Battlegrounds). The accessibility and simplicity made it popular among the battle royales and with other games. PUBG game is compatible and playable with a large number of devices. PUBG, Call of duty and Garena Free Fire are the most popular games with 3 modes solo, duo and squad. Solo means one to one. There will be a maximum of 100 players in a game and each of them is individual player. Duo means a group of 2 player and squad is a small group with 3-5 players. The players are taken to an island or to any maps using planes for survival to the end. The player who is alive by defeating other players is the winner at the end of the game. The weapons, health kits and other things needed for the game are available at the island itself. There are safety zones for the player to stay and survive. Since real time players interact in the game, the strategy or gameplay cannot e predicted. Even if we analyze a player, it is not necessary that next time the same player will be our enemy, so that we cannot predict the difficulty or winner of the game. There are different levels, tiers and ranks. Every player start from the lowest level 1 and the level increases as they play the game and earn points. There are seasons in BRG. In each season there are tiers or ranks. When the player earns points in the season, tier become higher. At the end of each game the player will get either positive or negative points. The player with highest tier or rank will get additional features, frames, points etc. Reward points are gained on reaching the highest tier but reaching the highest tier is very hard and there is a high chance of getting negative points. It is hard to sustain the highest tier because only a particular number of players can get the highest tier and title. A player is degraded if another player has more points than the player in the highest tier or rank. The player will get negative points if he or she cannot survive for a long time in the game or if they could not take much kills.

BRG has the facility to interact with other players through voice chat, messages and playing emotes while playing the game. Players from different region are united together. The game flow is unpredictable because humans are playing the game. The player gains a unique experience in each game interacting with different players. The rewards, prices, new dresses, weapons, armor, gun skin and other objects from seasons and events create interest in players to get a higher tier and unlock new rewards.

III. LITERATURE STUDY ON BATTLE ROYALE GAMES AND DDA

A number of studies were conducted on automatically tailoring the gaming experience using DDA. One of the challenges of game development is to design a game with the difficulty level that engages the user for a longer period of time. The game with greatest entertainment value has the challenge level that matches the skill of the player. A game with an adaptive Artificial Intelligence (AI) can add interest, create varied gaming experience and increase longevity of the game. Battle Royale Games cater to Maslow's hierarchy of needs. The lack of fulfillment of needs create an obsessive passion for games in players [1]. The concept of DDA to adapt to the players uses neural network trained with evolutionary algorithms and multilayer perceptron architecture [2]. Difficulty is dynamically balanced in MOBA games to improve player's entertainment by creating a computer controlled opponent that adapts dynamically to the player performance [3]. DDA is triggered based on Electro Encephalo Graph (EEG) headset to monitor and increase the excitement of the player [4]. The facial expressions and emotions of the player are captured to dynamically balance the game [5]. The paper [6] presents a systematic review to identify the relation between game types and gaming disorders. The trends in personalization of video game rules and player's preferences are examined in [7]. The results of path analysis based on the online questionnaire survey on Japanese students who play online games showed that Battle Royale Games are associated with aggressive feelings [8]. A meta heuristic Battle Royale optimization algorithm is proposed for the survival of the player in games [9]. The design requirements to balance games dynamically are discussed in [10]. The player's confidence to win can be increased by dynamically adjusting the difficulty in playing [11]. A set of variables to assess the skill of the player can be used to balance the difficulty [12]. The expected value of attributes at different levels of the game can be calculated with probabilistic approach [13]. The findings in [14] suggest that gamification has an impact on sustaining and encouraging game play. Several approaches to dynamically balance the gaming experience were reviewed in

diverse gaming genre [15] and one common aspect in all methods is the estimation of the level of difficulty of the player at any given instant using heuristic (challenge) functions. A probabilistic approach using DDA maximized player engagement by modeling the progression of the player [16]. Bayesian optimization techniques were used to design games which maximize the engagement of users allowing the players to attempt a game for a short period [17]. A study on how DDA can be implemented using Partially Observable Markov Decision Process (POMDP) uses influenced diagrams to reduce large problems to smaller and manageable units [18]. The physiological signals of the player were measured and analysed to determine the anxiety level of the player, which was chosen as the target affective state, to automatically adjust the difficulty in real time. Wearable biofeedback sensors and several physiological indices were explored to determine their correlations with anxiety [19]. The three approaches to measure the difficulty of a game genre are using formal model of game play, using features of the game and direct observation of the player [20]. There are embodiments of systems that perform automatic granular difficulty adjustment which is undetectable by user.

In multiplayer video games, Multiplayer Dynamic Difficulty Adjustment (MDDA) features are used to balance the challenge between differently skilled players [21]. It must be clearly understood how MDDA design is perceived by players. Some studies indicate that MDDA optimises challenge and performance but awareness of the presence reduces the effectiveness. The data on expectations of the player regarding the effect of components, features and attributes must be investigated from MDDA. The score difference between players is significantly reduced by DDA, allowing less skilled players to be more competitive against more skilled players [22]. Deep Player Behaviour Modelling (DPBM) uses deep learning techniques to create significant improvements in motivating the players and improving adaptability [23]. The machine learning approach to DDA with Partially Ordered Set Master (POSM) algorithm orders or sorts the difficulty settings from least to most difficult.

The characters and cartooning style in the Battle Royale Games attracted players to be addicted. These games are survival games with around 100 players in a game. To be a winner among higher player counts is a tense affair. Looting is an important part of a Battle Royale making the players scavenge for weapons and gear. The aim of the player is to prolong the game. Some of the challenges faced are:

- Anger or Frustration
- Internet speed
- Unknown players and their skills
- Low end devices

Frustration is the most common challenge that makes the player angry. The rank and level of players will be increasing gradually as the game progresses along with the level of difficulty. There are chances of getting negative points as levels progress. Continuous negative points disappoint and frustrate players making them to stop playing. Keeping the player challenged with an exotic gaming experience in interactive games is difficult as it is tough to estimate when and how to do game adjustment.

IV. PROPOSED MODEL WITH DDA AND ITS IMPLEMENTATION

The life cycle of a video game or video game development cycle includes concept, design, launch, and post-launch of the game. The ultimate aim of each game is to make players spend their maximum time in playing and retain the player's interest. But if the players get frustrated, they may stop playing. This may affect the ranking of game in the gaming industry. To avoid that, the solution for this frustration is implementing DDA in BRG. The emphasis of the framework with DDA helps game designers to better align the learning goals with game mechanics to produce more deeply effective game experiences. The DDA system includes adjustment actions and adjustment policies with proactive and reactive strategy.

The main thing that makes the players disappoint and frustrated is the negative points in the game. Getting negative points less than 4 for two or three times is negligible but more than that make the player frustrated for sure. A new player or players below a certain level never care about their point or rank. But a player who is going for a rank push will be frustrated with the negative points as he or she enters to a certain level where they start getting more negative points.

DDA is the method that automatically adjusts the difficulty of the game. By using DDA we can calculate the average points earned by a player in his or her each 10 games and if the average negative point of a consecutive 5 games or 5 games in a day is more than half of the average of the 10 games, then it is a big loss for his earned positive points. In such situation the player should be given a lobby with low rank than him or her. Thus, the player can earn positive points this time and thus the player can overcome his or her frustration and have a confidence that he can earn positive points in next game also.

When the game becomes too tough to progress through the challenges imposed by an AI-controlled environment, the proposed adaptive system can assist players by balancing the difficulty behind the scenes. This retains the interest of the player over time by allowing them to progress at a steady pace. The historical data on the player's game activity is used in this method. The following steps implement the proposed Dynamic Difficulty Adjustment in Battle Royale Games:

1. Analyze the performance of each player who reached certain level namely crown in PUBG, pro in Call of Duty and diamond in Free Fire.
2. Find the sum of with positive points in 10 matches.
3. Find the sum of the negative points of 5 matches.
4. Find the average of both positive and negative points. 1) Check whether the average of negative points is larger than half of the average of the positive points 2) Check whether there is a continuous negative point in consecutive 5 matches and whether the sum of that negative points is greater than 10 3) Allocate a lobby with players having less rank than this player if any of these conditions satisfies.
5. Update the sum of positive and negative points in each 24 hrs. Updating is done by adding the point of current match to the existing sum and the point of very first match will be excluded from the sum.
6. Repeat all these steps until the current season ends.
7. Make the sum of positive and negative points at the beginning of next season and perform steps 1 to 6.

CONCLUSION AND FUTURE WORK

Battle Royale genre has a profound impact on the video gaming industry. This paper is an attempt to systematize the scaling of difficulty in playing the Battle Royale Games PUBG, Call of duty and Garena free fire. The proposed scheme of Dynamic Difficulty Adjustment (DDA) provides efficient, promising and competitive results by collecting the player's game data to overcome the challenges and to reach more players. For the Battle Royale genre to flourish and open gates to contribute to the success of gaming industry, the overall game difficulty must be adjusted to the skill and expertise of individual players on the fly.

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