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**Formidable Fortress – A Level Based Artillery
Game Featuring Rule Based Dynamic Difficulty
Adjustment**

Master's Thesis (30 ECTS)

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Tartu 2025

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Abstract:

This thesis presents the design and development of Formidable Fortress, an artillery game featuring a rule-based Dynamic Difficulty Adjustment (DDA) system. Traditionally, games offer static difficulty settings at the beginning of the game. This method does not consider that the player's skill may improve during the game. DDA dynamically adjusts the game's difficulty to match the player's skill level and performance. This study explores a rule-based approach to DDA. The system has an initial evaluation phase where players from all experience ranges face the same level. After this evaluation, the game identifies the player's level and starts acting accordingly. The game was developed using the Unity game engine, and art assets were created in Aseprite. Playtesting sessions were conducted with interviews to evaluate the effectiveness of the rule-based DDA system. Qualitative feedback and observational data were collected to check player performance and engagement and identify design issues. The results demonstrate that the system mostly successfully adjusts difficulty to individual player skills after the initial evaluation phase. Limitations were identified from the player feedback, where experienced players found the initial skill evaluation phase overly simple. The study concludes that a rule-based DDA approach provides a practical solution for adaptive gameplay. This system may work in small-scale projects or games with limited computational resources. Future research should explore how to determine players' skill levels more efficiently and how to reduce the designer's workload.

Keywords:

Game Design, Level Design, Dynamic Difficulty Adjustment (DDA), Rule-Based Approach, Game Development, Artillery, Unity, Flow Channel, Mechanics-Dynamics-Aesthetics (MDA), Human-Computer Interaction

CERCS: P176 Software Engineering, P178 Human-Computer Interaction

***Formidable Fortress* – Tasemepõhine suurtükimäng, millel on reeglitel põhinev dünaamilise raskuse kohandamine**

Lühikokkuvõte:

See lõputöö tutvustab Formidable Fortress'i disaini ja arendust, mis on kahurimäng, kus kasutatakse reeglipõhist dünaamilise raskusastme kohandamise (DDA) süsteemi. Traditsiooniliselt pakuvad mängud staatilisi raskusastme seadistusi juba mängu alguses. See meetod ei arvesta, et mängija oskused võivad mängu käigus paraneda.. DDA kohandab mängu raskusastet dünaamiliselt, et see vastaks mängija oskuste tasemele ja sooritusele. Käesolev uuring uurib reeglipõhist lähenemist DDA-le. Süsteemil on algne hindamisfaas, kus igasuguse kogemustasemega mängijad alustavad samal tasemel. Pärast seda hindamist määrab mäng kindlaks mängija taseme ja hakkab vastavalt toimima. Mäng on arendatud Unity mängumootoriga ning kunstiresurssid on loodud Aseprite programmiga. Mängutestimise sessioonid viidi läbi koos intervjuudega, et hinnata reeglitel põhineva DDA süsteemi tõhusust. Mängija soorituse ja kaasatuse hindamiseks ning disainiprobleemide tuvastamiseks koguti kvalitatiivset tagasisidet ja vaatlusandmeid. Tulemused näitavad, et süsteem suudab pärast esialgset hindamisfaasi enamasti edukalt kohandada raskust vastavalt mängijate individuaalsetele oskustele. Samas tuvastati mängijate tagasisidest ka piiranguid. Kuna mängijad tulevad erineva taustaga, võib see, et kõigile pakutakse hindamisfaasis samu tasemeid, muuta kogunud mängijate jaoks selle faasi liiga lihtsaks. Uuring jõuab järeldusele, et reeglitel põhinev DDA-lähenemine pakub praktilise lahenduse kohandatava mängukogemuse saavutamiseks. See süsteem võib hästi toimida väiksemates projektides või piiratud arvutusressurssidega mängudes. Tulevased uuringud peaksid uurima, kuidas mängijate oskuste taset tõhusamalt kindlaks määrata ja kuidas vähendada disainerite töökoormust.

Võtmesõnad:

Mängudisain, tasemedisain, dünaamilise raskuse kohandamine (DDA), reeglitel põhinev lähenemine, mänguarendus, suurtükivägi, Unity, Flow-kanal, Mehaanika-Dünaamika-Esteetika (MDA), inim-arvuti interaktsioon.

CERCS: P176 Tarkvaratehnika, P178 Inimese-arvuti interaktsioon

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Introduction

Maintaining player engagement in a video game depends heavily on its capacity to deliver a balanced challenge [1]. Traditionally, games have employed static difficulty settings, requiring players to select a mode (e.g., Easy, Medium, or Hard) at the start of the game [2]. This approach offers some level of difficulty customization. However, it fails to adapt to the evolving skills of individual players [2, 3]. These static difficulty settings can result in either frustration from excessive difficulty or boredom from insufficient challenge.

Dynamic Difficulty Adjustment (DDA) systems have emerged as a solution to this problem by modifying the game's difficulty in real time based on player performance [4]. These systems aim to keep gameplay challenging yet enjoyable by personalizing the difficulty curve [4]. However, many existing implementations rely on complex procedural content generation (PCG) or machine learning algorithms, which can be resource-intensive and may lead to unpredictable or aesthetically unpleasing results [5, 6]. However, simple rules can effectively modify gameplay to suit player performance [4]. In the educational 3D game *Surviving Businessman*, the researcher used fuzzy logic to implement DDA. Fuzzy logic is a form of rule-based system. The game successfully increased player satisfaction by adapting to their skill level [7].

This study proposes a straightforward rule-based DDA system in the artillery game *Formidable Fortress*. Unlike PCG-driven methods, this system relies on handcrafted levels and a simple function that adjusts difficulty based on player shooting accuracy. The rule-based approach ensures that a game designer controls the player experience completely. The game dynamically switches between predefined difficulty modes. The primary objectives of this study are:

- To design and develop an artillery game featuring handcrafted levels and a rule-based DDA system.
- To evaluate the system's effectiveness in determining a player's skill level and selecting difficulty based on that.

To address scalability issues when creating multiple difficulty modes and explore practical solutions for reducing designer workload.

The feedback interview was designed to find the answer to the following questions:

- Is the simple rule-based DDA system effective in determining a player's skill level?
- What impact does the system have on player immersion and performance?

- Do the players notice any spikes at a difficult level?
- Do they get frustrated with the selected level?

The study also includes experimental playtesting with eight participants to evaluate the effectiveness of the rule-based DDA system. The testing involved observing gameplay and collecting qualitative feedback through post-game interviews. The results demonstrated that the rule-based DDA system can successfully determine the player's skill level and deliver difficulty based on that. However, the finding also highlighted issues in the evaluation phase of the game.

In the beginning, the game offers all players the same level to determine their skill level since, at this point, the game does not know the player's experience level. Expert players found this phase too simple. The rule-based system also increases the designer's workload, having to think about enemy wave configuration for multiple difficulty modes for each level. However, the algorithm can take some load off the designer by introducing adjustable features like speed, health, and dynamic movement. However, the designer must work more if the game has static difficulty settings (easy, medium, hard).

This thesis is structured as follows:

- Chapter 1 overviews related concepts, including game flow, difficulty balancing, and DDA systems.
- Chapter 2 details the game design and implementation process, including developing the rule-based DDA system.
- Chapter 3 presents the testing methodology, analyses player feedback, and evaluates the impact of the DDA system.
- Chapter 4 summarizes the key findings, discusses their implications, and suggests directions for future research.

This research contributes to game design by showing that DDA can be achieved with simple rule-based adaptive difficulty mechanisms. It also offers practical recommendations for scaling such systems across different game genres and reducing designer workload.

1 Game Design and Dynamic Difficulty Adjustment

In game design we shape the player's experience [3]. A game designer creates the game's rules and makes it fun [3]. Maintaining the difficulty balance is one critical challenge when designing a game [1, 2]. This balance in difficulty plays a significant role in keeping players' enjoyment. In the existing games, players usually have to select a difficulty mode at the beginning [2]. Another way to adjust the difficulty is to use Dynamic Difficulty Adjustment (DDA) [4]. DDA adjusts the game's difficulty based on players' performance. This chapter explores key ideas of game design, game flow, Mechanics, Dynamics, Aesthetics (MDA) framework, game difficulty, and DDA. It also explains the rule-based approach used in this thesis.

1.1 The Game Design Principles

Game design shapes a player's experience through interaction, challenge, and reward [3]. Designing for the player's experience is central to game design. One major challenge in designing games is that designers cannot directly control how players feel or experience the game [3]. In 2004, Hunicke et al., in the Mechanics, Dynamics, and Aesthetics (MDA) framework, named this problem the "second-order problem" [8]. The MDA framework suggests an approach to solving this problem.

Since it is impossible to impact the player's feelings directly, designers must work backward from the desired player experience to create mechanics and dynamics to make the player feel certain emotions and reactions [8]. Mechanics means the rules, algorithms, and basic functions- that define the game's operation. Play patterns like pacing and strategy development are created when players engage with the game mechanics. These patterns are called dynamics. The dynamics of a game give rise to aesthetics, which are the emotional responses and experiences of the player, such as fun, frustration, or a sense of achievement [8].

Game designers must focus on creating mechanics and dynamics that can indirectly shape the players' experience [8]. Because of this interaction, game design is a multidimensional field. The field of game design requires technical mastery, creative vision, and a thorough understanding of player psychology [1].

One of the most essential tools a game designer has is difficulty design [2, 3]. The difficulty level is part of the game mechanics. It influences how players engage with challenges and

progress through the game, and therefore, it significantly impacts the emotional highs and lows of the experience [8].

However, designing an appropriate difficulty curve for a game is very challenging [2]. The players come from diverse backgrounds in terms of experience. It is common to use a static difficulty for all players. A static difficulty curve often fails to account for this diverse skill level [4]. If a game is too easy, players might get bored, while if it's too complicated, they could become frustrated and lose interest [4]. More importantly, as the players keep playing a game, their skill sets may evolve differently [3]. So, after playing for a specific time, all the players may not have the same skill levels. The static difficulty settings ignore it [4]. Ignoring that the player's skill level is improved while playing a game may ruin the balance between game difficulty and players' skill level.

For example, if the difficulty is increased by giving players limited ammunition (mechanic), they will be tense as they consider how best to use these resources(dynamics). If they overcome a challenging situation like this, they will feel satisfaction. However, this satisfaction is not universal. It depends on each player's skill level and behaviours, making prediction difficult.

A game designer cannot directly influence players' feelings; they must use mechanics [8]. However, players with different skill levels or preferences may interpret the same mechanics differently [2, 3]. For example, a skilled player may get excited while interacting with the same system, while a novice may get frustrated. To address this problem, designers rely on iterative playtesting [9].

Designers gather information and observe player reactions during these playtesting sessions [9]. Based on their observations, they improve the game mechanics to affect the dynamics for different kinds of players. However, despite extensive testing, player reaction variability remains a significant problem [2].

One way to address this issue is to dynamically adapt to the difficulty level in response to players' performance during the game [4]. Changing the difficulty level during the game keeps it suitable for each participant. DDA offers a means of dynamically altering the game's dynamics by adjusting game mechanics during gameplay in response to player performance [4]. The real-time adjustment can also resolve the second-order issue. It can help close the gap between mechanics and aesthetics. Removing the gap between mechanics and aesthetics

ensures that the emotional experiences align with the designer's intentions regardless of the player's skill level [8].

The rule-based DDA system suggested in this thesis tackles the second-order problem by altering the degree of difficulty using predefined mechanics and a simple function. This system uses performance-based difficulty switching to ensure constantly engaging player experiences. This study aims to ensure that players with different skill levels enjoy the desired aesthetics, thrill and satisfaction during the game.

1.2 Game Flow and Engagement

Mihaly Csikszentmihalyi introduced the concept of flow. It describes a state of deep engagement and enjoyment when a person is fully absorbed in an activity [3]. In the context of games, flow occurs when the challenge in the game lines up with the player's skill level.

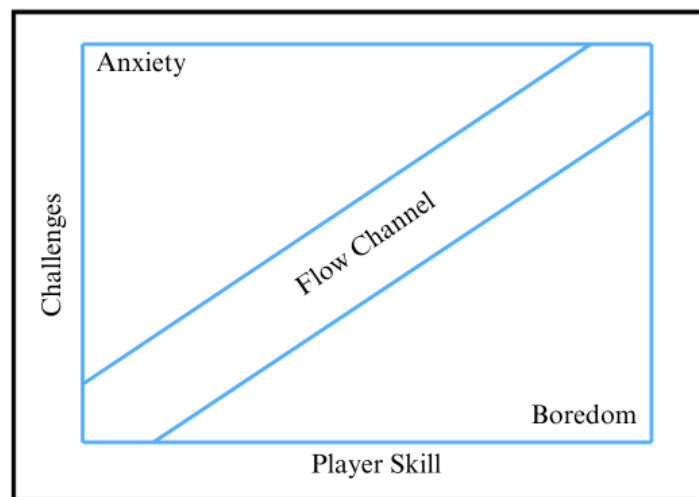


Figure 1. Game Flow (Schell, 2014).

As shown in Figure 1, highly skilled players may become bored when the challenge is too low. On the other hand, if the challenge is too high, low-skilled players will feel anxious. If the balance is maintained, players will be in the flow channel. Successful game design carefully adjusts the difficulty curve to keep players in this state [3].

In an artillery game, achieving the flow means balancing the rules and actions of the game, such as aiming, shooting, and configuring enemy waves (mechanics). It also includes how players interact with these mechanics, such as deciding when to shoot, where to seek, and which enemy to shoot first (dynamics). The game must balance the difficulty of aiming and

shooting with the player's strategies for killing enemies. This balance helps the player feel challenged and capable, leading to an enjoyable experience.

If the game presents overly challenging enemy waves to a novice player, they will feel discouraged. On the other hand, if a highly skilled player faces very simplistic enemies and waves, they may lose interest.

Dynamic difficulty adjustment (DDA) can be key in addressing this balance. This way, the game adapts to the difficulty based on the player's performance. By implementing rule-based DDA, the game tries to maintain the flow state for players across different skill levels.

1.3 The Mechanics, Dynamics, and Aesthetics Framework

Hunicke, Le Blanc, and Zubek (2004) designed and developed the MDA framework [8]. It gives a structured approach to explaining how games create the player experience. The fundamental rules, algorithms, and systems that define how a game functions are called the Mechanics. When players interact with the gameplay, patterns of gameplay appear. These are called dynamics. The emotional response and experience that players feel are the aesthetics [8].

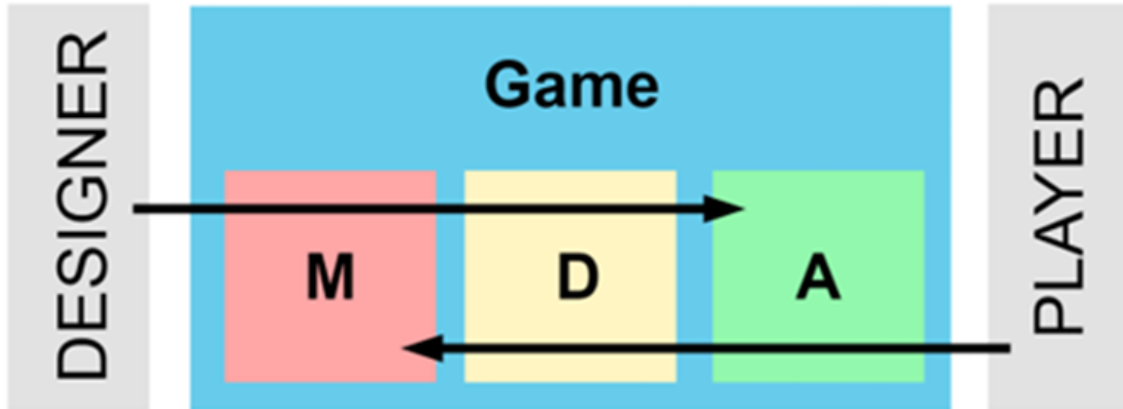


Figure 2. MDA Framework (Hunicke, 2004).

Figure 2 demonstrates the model from the designer's and the player's perspectives. This framework helps game designers create games that elicit appropriate emotional reactions in players. In an artillery game, mechanics, dynamics and aesthetics can be defined in the following way:

Mechanics: The players aim and shoot at enemies. The game has different types of enemies

Dynamics: When playing an artillery game, players develop strategies. These strategies

include prioritizing which enemy to kill first, keeping track of ammunition, or timing the shot. These dynamics arise when players interact with the mechanics mentioned above.

Aesthetics: Due to the dynamics, players may feel the thrill of landing a perfect shot, overcoming a tough enemy, or the tension of defending the fortress.

This interplay guarantees that the game offers a meaningful experience by carefully adjusting the mechanics or dynamics to achieve the desired aesthetics.

In the context of the artillery game made for this thesis, the rule-based Dynamic Difficulty Adjustment (DDA) system fits into the MDA framework by using predefined level transitions as a core mechanic to dynamically adjust the player's experiences. The game determines the player's skill level by the percentage of accurate shots. Then, it selects an appropriate difficulty level (easy, medium, or hard) for the next level. This adaptive mechanics makes sure that the game remains balanced. Each level has three maximum modes: easy, medium, and hard. Thus, designers will not have to work on an exponentially more significant number of levels.

For example, when the system identifies a skilled player who consistently makes accurate shots, it dynamically increases the difficulty by switching to hard mode at the next level. This adjustment creates dynamics where players must refine their strategies for a new challenge. The game ensures that the dynamics remain fresh and engaging by aligning the mechanics of difficulty adjustment with the player's evolving skill level. Dynamically adjusting the difficulty maintains the desired emotional experiences throughout the gameplay journey.

1.4 Game Difficulty and Adaptation

Game difficulty is the level of challenge a player experiences while playing the game. Players must overcome these obstacles to progress [2, 3]. Many factors, including enemy strength, availability of resources, time limit, and the complexity of tasks, can influence difficulty [2]. If a game has a well-designed difficulty curve, that makes sure that the game progresses in a way that balances the player's growing skills [3]. Offering static difficulty settings- where players select "Easy," "Medium," or "Hard" modes at the start of the game is a common choice in a lot of games [2]. However, this is a one-size-fits-all solution. These settings don't consider the difference in player skill or change as players get better or have more difficulty while playing, which could cause disinterest or annoyance [4].

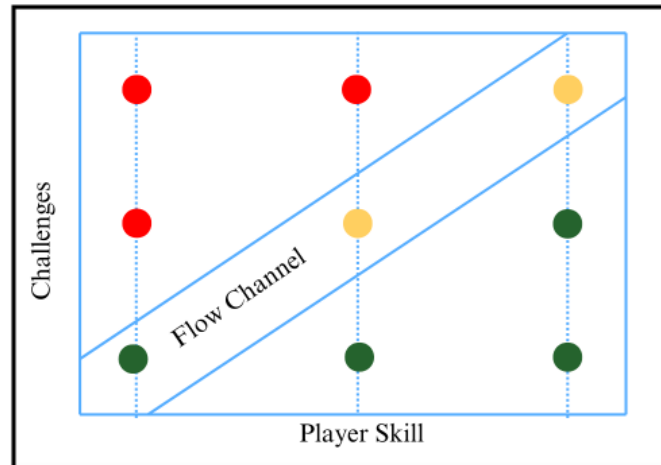


Figure 3. Flow Channel in Static Difficulty Settings.

As shown in Figure , static difficulty settings fail to consider that players skill can improve during the gameplay.

Game Adaptation is a game design technique that personalizes the gaming experience to match the player’s skill level, preferences, or behavior [2, 3]. This tailoring ensures a balanced experience by adjusting difficulty, pacing, and narrative choices. In adaptive systems, the game balances in response to players' performance and actions [4]. For example, an adaptive system in an artillery game may increase the number of enemies for skilled players and reduce it for struggling players. The game can cater to a broader audience by adapting to the player's needs [9].

Importance of Difficulty and Adaptation

Balancing skill and challenge are essential for player retention and enjoyment [3]. Games that don't adapt to players' skill levels run the danger of alienating their audience; while skilled players could feel bored and unchallenged, novices might find static difficulty excessively harsh [4]. By preserving the delicate balance required to keep players in the flow, adaptive systems solve these problems [5].

Challenges of Game Adaptation

Despite its benefits, game adaptation comes with challenges. Advanced adaptive systems often rely on procedural content generation or machine learning, which can produce inconsistent results, such as poorly designed levels or unexpected difficulty spikes [5]. These systems can also be resource-intensive, making them impractical for small development

teams or games targeting lower-end hardware [5, 6]. Furthermore, if players notice at runtime that the game is lowering difficulty, it may give the impression that there is no fixed challenge to overcome [2]. Designer crafted content offers a compelling alternative by maintaining design quality and ensuring predictable, player-centered adjustments [3]. When paired with simpler, rule-based adaptation techniques, handcrafted contents may also ensure a mostly predictable experience [4].

The rule-based DDA system suggested in this thesis attempts to address these issues by combining the flexibility of dynamic difficulty adjustment with the purposefulness and visual appeal of handcrafted levels. This method produces a balanced experience for players with different skill sets and guarantees that game difficulty changes constantly in response to player performance.

1.5 Dynamic Difficulty Adjustment (DDA)

Dynamic difficulty adjustment (DDA) is a game design technique that modifies a game's difficulty in real-time based on the player's performance [4]. Unlike static difficulty settings, DDA ensures that players are consistently presented with challenges that match their skill level, maintaining engagement and avoiding frustration or boredom. By dynamically tailoring the gameplay experience, DDA keeps players in the flow channel, where the balance between challenge and ability fosters immersion and satisfaction [4]. This mechanism is particularly effective in ensuring that games remain accessible to novice players while continuing to challenge seasoned ones, enhancing player retention and enjoyment.

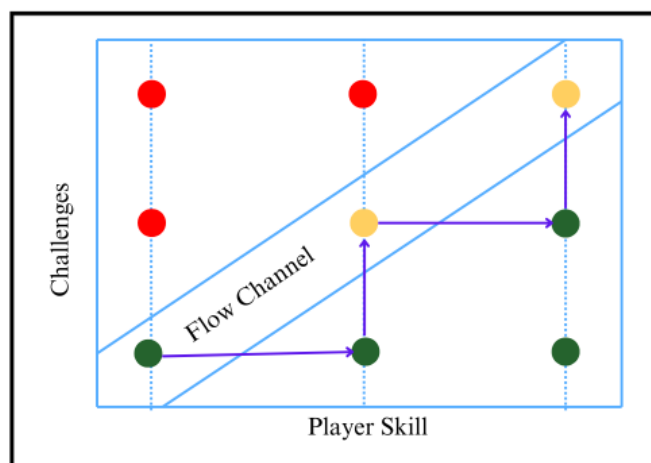


Figure 4. DDA keeps player in flow channel.

Figure 4 shows, how dynamic difficulty adjustment can try to keep player in flow channel by evaluating their skill level during the gameplay.

Types of DDA Systems

We can broadly categorize DDA systems into procedural, algorithmic, and rule-based approaches [4, 5]. Procedural systems use real-time content generation to modify game elements based on player behavior, such as spawning enemies or altering terrain [5]. Algorithmic systems, often using machine learning, predict player responses and adapt gameplay accordingly. While these approaches offer flexibility, they can be computationally intensive and may produce unpredictable outcomes [5]. In contrast, rule-based DDA systems use predefined rules and thresholds to adjust difficulty. These systems are simpler to implement and more predictable.

1.5.1 Rule Based DDA

Rule-based Dynamic Difficulty Adjustment (DDA) is a system that modifies game difficulty by using predefined rules and performance thresholds. This approach ensures predictable, consistent adjustment [4]. It evaluates player metrics like accuracy or completion time.

The rule-based DDA system developed for this artillery game dynamically adjusts the difficulty of gameplay by switching between predefined Easy, Medium, and Difficult levels. Performance metrics shooting accuracy is used to make this adjustment. For instance, players with high accuracy will encounter tougher enemies and faster gameplay dynamics in future levels. The struggling players will transition to levels with fewer enemies and slower pacing.

Advantages

Rule-based DDA offers several key benefits for artillery games:

Handcrafted Quality: Using predefined levels, the system maintains handcrafted designs' aesthetic and gameplay quality. It helps in avoiding the inconsistency often seen in procedurally generated content [5].

Simplicity and Accessibility: Rule-based DDA is computationally simple and easier to implement. It is suitable for smaller development teams or projects targeting hardware-constrained platforms [7].

Predictability and Control: If the designers have full control over difficulty transitions, it ensures smooth and intentional adjustments that align with the desired player experience [3]. In rule-based DDA, that predictability is preserved.

1.5.2 Addressing the Challenges in DDA

The goal of DDA is to consistently provide a suitable degree of challenge for every player [4]. DDA maintains their interest and encourages them to play and retry the game. Yet, several problems can arise when designing a game with DDA.

Transparency and Player Perception

One key challenge in DDA is maintaining transparency without breaking player immersion. Sudden or obvious difficulty changes can make the system feel artificial and detract from the player's sense of achievement [2]. This issue can be avoided by letting players an option to play with DDA or not.

If players notice at runtime that the game is adjusting (lowering) difficulty, players may think that there is no fixed challenge to overcome [2]. If the game starts lower difficulty level, it can be hard for players to perceive their improvement.

To solve these problems, DDA should be used only to increase the difficulty, and it should not be noticeable to the players [2].

Exploitation

Players can also start exploiting the DDA feature of the game [2]. The Incredible Hulk made by PlayStation 2, faced severe criticism for lowering the difficulty at runtime. All these problems arise from lowering the difficulty of the game [2].

The exploitation can be easily avoided if the game only uses DDA for increasing difficulty, DDA should not lower the difficulty at any point in game [2].

Consistency

Implementing DDA effectively is technically challenging and the use of PCG in creating this mechanism can be resource intensive [5]. Poorly designed systems can lead to more issues than they solve, such as uneven difficulty spikes [5]. For example, if the algorithm is responsible for deciding how many enemies will be generated based on players performance, there can be situation where the algorithm is spawning unusual number of enemies. This will be difficult for the player to handle and cause a performance bottleneck.

To solve the above-mentioned issues, the game made for this study, rule-based DDA system never lowers the difficulty. So, all difficulty modes of level three are more difficult than Level two and so on. The game algorithm does not decide how many enemies to spawn.

1.6 Case Studies in DDA

A lot of games experimented with dynamic difficulty adjustment (DDA) to try and increase player engagement. This section explores examples of existing games that effectively utilize DDA systems. By examining these studies, the strengths and limitations of different DDA methodologies can be understood.

1.6.1 Existing Games with DDA

Two notable examples, *Bejeweled* and *Surviving Businessman*, employed unique approaches to integrating DDA into their gameplay mechanics. *Bejeweled* employs DDA to maintain player interest in a puzzle-solving context. *Surviving Businessman* uses DDA in an educational setting to balance learning and gameplay. These games highlight how DDA can be used in different genres.

Bejeweled by EA

In the match-three game *Bejeweled* (Figure 5), released by Electronic Arts in 2013, players exchange nearby objects on a board to align three or more identical objects vertically or horizontally, removing them from the board [10]. Every level has distinct objectives, such as reaching a particular point total in a set number of moves. Players advance from lower to higher levels by successfully finishing each of the more than two hundred stages; the following levels are only unlocked upon victory.

Two weeks after the game's initial release, the DDA experiment on the players started. The main goal of this experiment is to keep players interested and engaged throughout the game. They start by visualizing the player's progression through the game as a map made of many player states [10].

As players progress, they move from one state to another. The transition probability depends on how difficult the game is in each state. So, to keep players engaged, they tried to maximize these transitions. Then, dynamic programming solves the difficulty function. Researchers conducted the DDA experiment on this game after its global release and observed a significant increase in core engagement [10].



Figure 5. *Bejeweled* by EA.

Surviving Businessman

The video game *Surviving Businessman* (Figure 6) is a 3D educational game designed to teach users the HTML programming language [7]. Set on an island with various environments, such as a castle, forest, and catacombs, players must find keys to unlock gates leading to different stages. Each stage involves navigating mazes, fighting enemies, and answering HTML-related questions posed by agents. With eight stages, the goal is to open all four business gates in the final stage to acquire HTML knowledge and claim a treasure as the game's reward [7].



Figure 6. *Surviving Businessman*.

This game uses fuzzy logic to achieve DDA. Using fuzzy logic eliminates the need for learning data like AI or machine learning. Instead of adjusting difficulty between levels, this game applies DDA in real-time during gameplay. It dynamically adapts the difficulty of questions, quizzes, battles, and mazes to match the player's skills [7].

The system uses fuzzy sets to quantify a player's battle and maze navigation skills. These sets capture battle duration, enemy damage inflicted, maze traversal time, trap encounters, and requested assistance frequency. Then, these fuzzy sets are used to determine the player's difficulty classification level within the game. The algorithm implemented here also showed a significant rise in player engagement [7].

1.6.2 Comparison with Rule-Based DDA

The rule-based DDA system in the artillery game described in this thesis differs from the approaches used in *Bejeweled* and *Surviving Businessman*. It relies on simple straight forward rules rather than complicated systems.

Application in Smaller Teams

The rule-based approach also highlights its practicality for smaller development teams or indie studios. Unlike the state-based system in *Bejeweled*, which requires complex algorithms, rule-based DDA is simpler and more accessible. Predefined levels eliminate the need for computationally intensive content generation. This approach offers indie developers an efficient way to create adaptive gameplay experiences while maintaining artistic and design quality.

1.7 Designing Games with Rule-Based DDA

Since DDA adjusts the game difficulty to players' performance, the game design needs to have a mechanism for evaluating player's performance. Based on this evaluation, the game will decide to adjust its elements. Therefore, there are two crucial parts of designing a game with DDA [2]:

- a. Performance Evaluation
- b. Adjustment Mechanism

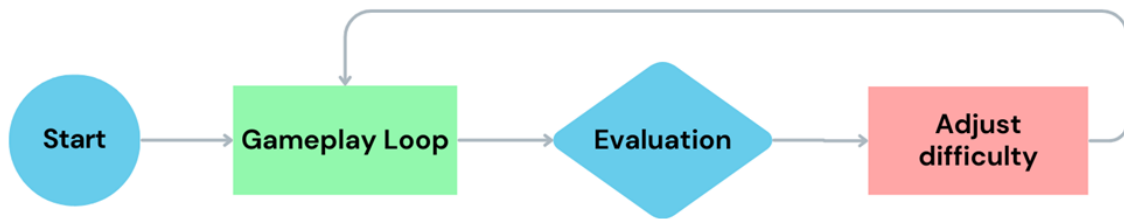


Figure 7. Game Loop with DDA.

The game made in this thesis also has two phases: evaluation and adjustment (Figure 7). At the beginning, all players must play at the same level. This is where game determines players skill level. After this phase, the game chooses from the predefined difficulty modes for each level. At the end of each level, performance evaluation is performed again, and a difficulty mode is determined for the next level.

2.7.1 Evaluation

Effective performance evaluation is the foundation of any Dynamic Difficulty Adjustment (DDA) system. This thesis presents an artillery game that assesses player performance using measurable metrics to reflect skill and engagement. The key metric is:

Shooting Accuracy: The ratio of successful shots to total shots fired, indicating the player's precision and efficiency.

The evaluation is done at the beginning and at the end of each level in this game.

2.7.2 Adjustment Mechanism

Difficulty Switching: After calculating the performance score, the system uses predefined thresholds to select the next difficulty level:

- **Easy Mode:** Activated if the performance score is below 40%, indicating the player is struggling.
- **Medium Mode:** Assigned if the score is between 40% and 70%, reflecting balanced gameplay.
- **Difficult Mode:** Triggered for scores above 70%, indicating high player skill.

These thresholds are carefully refined through playtesting to ensure engagement. For example, if a player demonstrates high shooting accuracy, the system will transition them to a more challenging level featuring faster enemies or more obstacles. On the other hand, if a

player struggles with accuracy or takes too long to finish, the system selects an easier mode in the next level.

2 Implementation

The primary goal of this thesis was to implement an artillery game with rule-based dynamic difficulty adjustment (DDA). Through an analysis of observational data and interviews conducted during the playtesting sessions, this study tried to find issues in the system and recommend future improvement.



Figure 8. Screenshot from the game.

The game is a simple artillery game where players shoot at approaching enemies and defend the fort, as shown in Figure 8.

2.1 Rule-Based DDA Design

The first step was to do a thorough theoretical analysis. This involved reading relevant articles, scientific papers, book chapters, and conference talks featuring dynamic difficulty adjustment (DDA). After that, criticisms mentioned about static difficulty were listed. This helped me understand the importance of DDA.

For understanding DDA was, a review of existing literature on DDA was done, game design frameworks, and player engagement theories. criticisms of DDA mentioned by the researchers were noted. Insights of experts who have studied or implemented DDA in games were reviewed as well. This review provided a broad understanding of the current state of DDA, its applications, and its limitations. It also highlighted areas of disagreement in the literature.

This reading revealed recurring issues, such as poor adaptability to different player skill levels, overreliance on complex algorithms, and potential performance drawbacks. These insights informed the need for a simple DDA system.

For a better understanding of maintaining player engagement by balancing the game's difficulty, Flow Theory was explored as a framework. Flow theory, proposed by Csikszentmihalyi, suggests that players experience the most enjoyment when they are in a state of "flow," where the game's challenge level is perfectly balanced with their skill level. Players become frustrated if the game is too difficult; if it is too easy, they get bored. The ideal state is where players are continuously challenged but not overwhelmed. In the context of DDA, this theory guided the development of a system that adjusts the difficulty in real time to maintain this flow state. The goal was to create a DDA system that could dynamically adjust the difficulty channel, ensuring that the game remains engaging for players of varying backgrounds and skill levels.

The MDA framework was explored to understand how to influence player engagement through game design. In the context of DDA, this relates to how players adapt to changing difficulty levels and how those changes affect their gameplay strategies. The goal of the DDA system is to maintain a positive aesthetic experience by ensuring that the game remains challenging but enjoyable. By analyzing the game through the MDA framework, it was possible to understand how changes in mechanics (such as difficulty adjustments) would influence player dynamics. This analysis was important in designing a DDA system that adjusts difficulty.

Various DDA techniques in existing games were studied, including rule-based systems, machine-learning approaches, and procedural content generation. The literature revealed significant disagreements among designers and researchers regarding the best DDA approach. These disagreements often centered around the trade-offs between computational complexity and adaptability. This analysis highlighted the need for a more straightforward, yet effective DDA approach that could be widely applicable without the drawbacks of more complex systems.

The artillery game *Formidable Fortress* revolves around a central theme of DDA. It uses a rule-based DDA system to maintain optimal player engagement and attempts to provide players with a proper difficulty level. The gameplay involves protecting a building with a powerful cannon from approaching enemies.

3.1.1 Design Considerations

Theoretical integration played an important role in designing the artillery game *Formidable Fortress*, particularly in applying established DDA theories. These theories provided a framework to ensure that DDA was effectively incorporated into the game.

In this game, DDA is used only to increase the difficulty of the game because, in this way, the program does not need to identify why the player is doing well. The game never decreases difficulty between levels, which means all difficulty modes of the level are more difficult than the previous level. The following things are considered while designing DDA:

- DDA is used only to increase the game's difficulty.
- If a level has "Easy" and "Hard" modes, both are more difficult than the previous level.
- Decision points determine which difficulty mode will be selected in the next level.
- The algorithm only decides which pre-designed difficulty will be selected.
- The difficulty is adjusted only after the completion of a level, ensuring that players do not detect the DDA mechanism during gameplay.

3.1.2 DDA Design

Based on the above considerations, the rule-based DDA mechanism was built. Initially the game has no information about the players skill level. Therefore, all the players enter the same level. Then after this first evaluation, the game starts to branch out into easy and hard difficulty modes.

In the evaluation phase, the player performance metrics are measured against the predefined threshold for that level. If the players' performance metric is above the threshold, the player will get the hard mode. If the players' performance metric is below or equal to the threshold, the player will get the easy mode.

A level will have a maximum of three difficulty modes. If a player performs well in hard mode of a level, they will get the hard mode in the next level as well. If the player cannot cross the predefined threshold in a hard mode, they will get the medium difficulty mode in next level. Similarly, if a player does well in a medium mode of a level, they will get hard mode in the next level. But, if they do not perform well in the medium mode, they will get

the easy mode. If a player is not performing well in easy mode, the game will keep offering the easy mode in the next level as well.

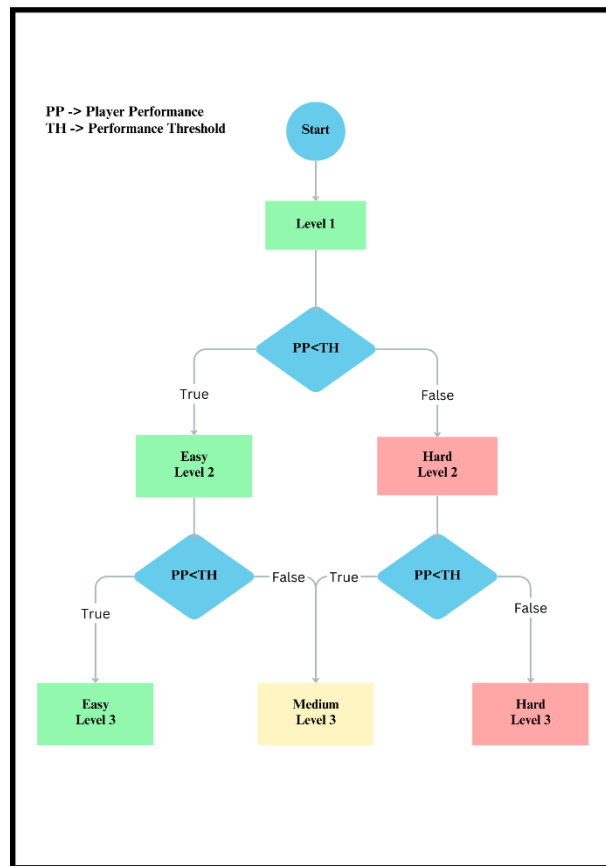


Figure 9. DDA design.

Figure 9 explains how the difficulty modes are selected. When the game starts, at level 1, everyone has the same difficulty. After the statistics about the player's shot accuracy have been established and the user has completed initial levels, the game compares the performance stat against a pre-defined threshold. Then, based on this comparison, the game starts selecting the appropriate difficulty mode for the player.

2.2 Game Design

Formidable Fortress is an artillery game where players aim and fire from a cannon mounted on top of a building. The goal is to protect the building from the waves of approaching enemies. As the guardian of the fortress, your mission is to target and eliminate enemies before they can damage your stronghold. Once the player has passed some levels, the game compares their performance against a predefined threshold. Based on this comparison, the

game decides the difficulty mode of the next level. This process repeats at the end of each successful level.

3.2.1 Game Mechanics

The game is played by tapping or clicking on the screen for aiming. As shown in Figure 8, using the projected arc, players can drag to modify the path and aim at a target. The game features a variety of enemies each with unique behaviors and vulnerabilities. Some enemies charge directly at your building, while others attack the fortress from a distance.

There is limited ammunition, so players strategically manage and use the ammo throughout the game. Every time an enemy breach the fort, its health is reduced. The game offers several levels, each presenting new challenges and increasing difficulty and number of enemies in the waves. The game's simple control lets the players focus on precision aiming, making it accessible for players of all skill levels.

Once the enemy gets too close to the tower, it is impossible to hit them. If the player runs out of ammo before killing the desired number of enemies, or the building has lost all the health points the level fails.

3.2.2 Enemy Design

The enemies are designed based on the following difficulty criteria:

- Enemy Type (Ground, Air).
- Enemy Speed (Fast/Medium/Slow).
- Enemy Health (One/Two).
- Enemy Count at each level.
- Attack Type (Fort Breach/ Shoot at Fort).
- Movement Type (Predictable/Unpredictable).

The game has 10 types of enemies:

- Slow ground enemy with one health point.
- Medium ground enemy with one health point.
- Fast ground enemy with one health point, can shoot at fort.
- Slow ground enemy with 2 health points.
- Medium ground enemy with 2 health points.
- Slow air enemy.

- Medium air enemy.
- Fast air enemy.
- Slow air enemy with unpredictable movement.

Figure 10 shows the basic enemy design of the game. Variation is created during runtime by giving the enemies back and forth unpredictable movements and multiple lives.

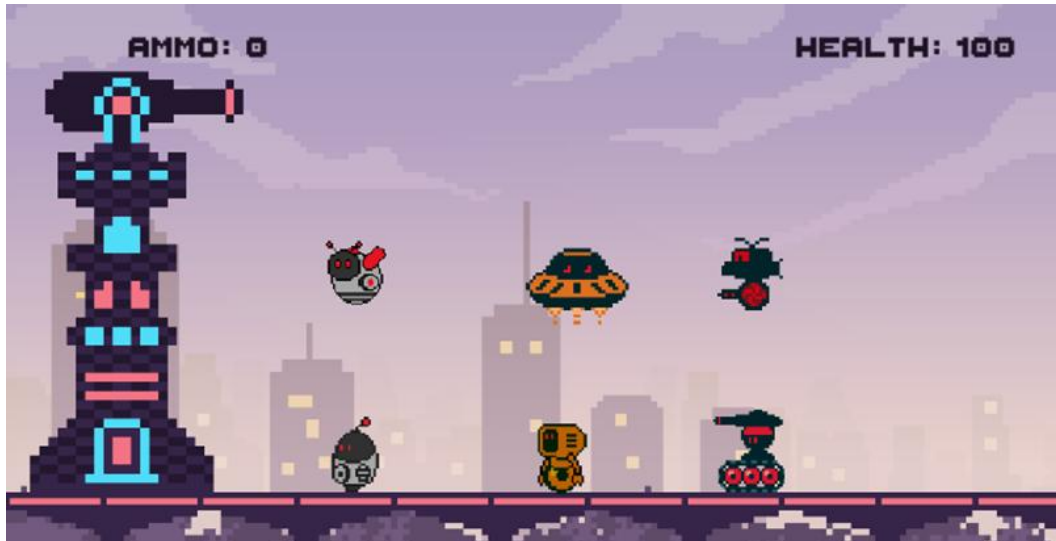


Figure 10. Enemy prefabs in Unity.

3.2.3 Level Design with DDA

The first three levels are designed without difficulty modes. It was difficult to predict user skill from one level, since some players needed time to adjust to the shooting technique. At the end of these three levels, the game determines the player's skill level. Starting from level four, the game starts to determine the appropriate difficulty mode for the player.

As explained in Table 1, each difficulty mode in a level has the same number of enemies in total, but there is variation in the types of enemies and their numbers. For example, both easy and hard mode in level 4 has 15 enemies in total. But unlike the hard mode, the easy mode does not have any fast air enemies.

All the difficulty modes (easy, medium, and difficult) of a level spawn an equal amount of enemies. However, the easy modes have few amounts of difficult enemies, like enemies with unpredictable movement and enemies with higher speed.

Table 1. Level Design

Level/ Difficulty Mode	Enemy Type and Count	Total Enemy Count
1	5 slow ground enemies	5
2	5 slow ground enemies, 3 medium ground enemy	8
3	6 medium ground enemies, 3 fast ground enemies, 3 slow air enemy	12
4 Easy	3 slow ground enemies, 5 medium ground enemies, 3 fast ground enemies, 4 medium air enemies	15
4 Hard	3 medium ground enemies, 8 fast ground enemies, 4 fast air enemies	15
5 Easy	3 slow ground enemies with 2 lives, 5 medium ground enemies, 4 fast ground enemies, 3 fast air enemies, 5 slow ground enemies with unpredictable movement	20
5 Medium	3 medium ground enemies with 2 lives, 5 fast ground enemies, 4 fast air enemies, 3 fast air back and forth, 5 medium ground with unpredictable movement	20
5 Hard	5 fast ground enemies, 3 fast ground enemies with 2 lives, 3 fast air enemies, 4 fast air with unpredictable movement, 5 fast ground enemies with unpredictable movement	20

Figure 11 shows a stage of the easy mode from level four. This mode mostly has enemies with low speed and fixed movement. The enemy waves spawned at this mode are spread out. Therefore, even novice players have enough time to strategize and shoot the enemies one by one.

Figure 12 shows a hard level from level five. This level has a high number of enemies with high speed, unpredictable movement and enemies who can shoot at the fort. This configuration makes this level very difficult, making it suitable for expert players.



Figure 11. Easy difficulty mode from level four.



Figure 12. Hard difficulty mode from level five.

3.2.4 Objective and Winning Condition

The primary objective of the player is to prevent the enemies from breaching the fort and damaging it. The goal at each level is to survive the attack from enemy waves with a fixed amount of ammo. At some points in the game, players will face powerful boss enemies with enhanced abilities and health.

3.2.4 Game Development Tools

The game assets are made in Aseprite, and the game was developed with Unity¹. Unity ensures faster development, allowing us to focus on the game's design. Aseprite excels in pixel art creation.

Unity Engine

Unity is a game development platform that lets you create 2D, 3D, AR, and VR games (Figure 13). It's easy to use and works on many devices like phones, computers, and consoles. The Unity game engine was used because of the author's familiarity with it. Using the observer pattern with Unity's scriptable objects and events, a modular event-driven system was created in the beginning. After that, adding new enemies and levels became easier. The levels are also made to be independent of each other, which makes the testing of new levels faster.



Figure 13. Unity Logo

Aseprite

Aseprite² is a simple tool for creating pixel art and animations (Figure 14). It's user-friendly and perfect for making sprites for games and other projects. Aseprite is also used because of my familiarity with it and my personal preference for pixel art. Making pixel art and animation with this tool was easy and efficient.



Figure 14. Aseprite Logo

Itch.io

Itch.io³ was used as the platform to upload and showcase the game (Figure 15). This platform helped in distribution for playtesting and gathering feedback from players.



Figure 15. Itch.io Logo.

¹ Unity Game Engine, <https://unity.com/>

² Aseprite, <https://www.aseprite.org/>

³ Itch.io, <https://itch.io/>

Git

Git⁴ was used as the version control system throughout the development process (Figure 16). It was used to store the code. Git reduced the risk of losing progress or introducing unintended issues during iterations.

These tools ensured the delivery of a polished game. Each tool was involved in a specific aspect of the development process from creating assets to distribution of the game.



Figure 16. Git Logo.

⁴ Git, <https://git-scm.com/>

3 Testing and Result

In this thesis, it was explored whether the rule-based dynamic difficulty adjustment (DDA) system can determine players skill level and adjust difficulty based on it. Given the subjective nature of player experience, a qualitative approach was chosen. This approach provides insights into player's experiences, emotions, and feedback. Quantitative methods were not used because they are more suited to measuring objective outcomes [11]. Qualitative methods are better suited to understanding how players interact with and perceive the gameplay [11].

The game was first tested in University of Tartu, 2024 Expo. Based on the player feedback, a sharp rise in difficulty was identified in a few places. These rules were updated to achieve a smoother experience.

After an initial refinement and bugfix, the playtesting sessions were conducted online. Participants played with the prototype and experienced the DDA system in action. During the sessions, they were observed. After each session, they were asked open-ended questions to share their honest opinions and feedback. This ensures that the data collected reflects their unique experiences. This combination of observation and feedback forms the foundation for evaluating the effectiveness of the rule-based DDA system and identifying areas for further improvement.

3.1 Participants Selection and Play Testing

To evaluate the effectiveness of the rule-based Dynamic Difficulty Adjustment (DDA) system implemented in the game, a structured playtesting process was conducted. The playtesting involved participants from diverse gaming backgrounds. It helped in gathering a wide range of perspectives and feedback. This section outlines the participant selection criteria and detailed description of the playtesting process.

3.1.1 Participant Demographics

The purpose of qualitative study is to find out what doesn't work in a design [11]. In the case of this game, this study checks if the rule-based DDA system works for a level-based artillery game. Jakob Nielsen's Usability Testing Theory suggests that testing with as few as 5 participants can uncover approximately 85% of usability issues [12].

Because of this, a total of eight participants were selected for this study, which is a small sample size compared to quantitative studies. While five participants may have been adequate for identifying key issues, eight users allow for a broad selection of players with various experience levels in gaming. This approach ensures that insights were gathered from a wide range of perspectives, from casual gamers to experienced players.

3.1.2 PlayTesting Process

The playtesting sessions were structured to capture detailed observations of gameplay issues and player reactions. Each session included:

- **Duration:** Participants finished playing all the levels and interacted with the underlying DDA system.
- **Levels Played:** Players were asked to play as many levels as they want. All of them finished playing the game.
- **Documentation:** The playtesting sessions were recorded to observe the difficulty level obtained by the players and to see whether they had any issues with the game mechanics. valuable data was obtained for later analysis from this recording and observation.
- **Feedback:** Participants gave feedback immediately after the playtesting sessions. The interview was designed questions keeping the following things in mind:
 - Whether there was any sudden jump in difficulty level?
 - Does the player stay happy with the difficulty in the last two levels?
 - Do they have any suggestions for improving game mechanics or level design?

Players were not notified of the DDA system beforehand.

3.2 Data Collection

The data collection includes two main parts. One is the observation of players' interactions during the gameplay, and the other is the feedback collected immediately after each play-testing session.

3.2.1 Observation

While reviewing the screen recording of the playtesting sessions, I observed and noted players' interactions. Observations were structured around an observation guide to ensure consistency. This included:

- Players' initial reactions to levels one to three.
- Does the player get bored or frustrated as the game starts to select difficulty mode from level four?
- Is the player satisfied with the progression of difficulty once the game starts selecting it?

Observations were made on whether the players were struggling or breezing through the game. It was also noted if players seemed aware of changes in enemy behavior and level complexity.

3.2.2 Player Feedback

After each playtesting session, feedback was collected in a semi-structured format. The participants were given structured forms, which were also included with the web version of the game available on itch.io.

The forms had a mix of short answers and open-ended questions. Using forms makes sure that consistent feedback was collected from all participants. Open-ended questions provided detailed feedback. The participants expressed their thoughts in their own words. The feedback form was designed depending on the following themes:

1. First Impressions

Participants shared their initial thoughts upon starting the game and their overall feeling. The purpose was to see their emotional response.

2. Previous Gaming Experience

Information about players' gaming habits were collected, including:

- Frequency of playing video games.
- Preferred genres and familiarity with artillery or skill-based games.
- They were asked about their experience with games that adjust difficulty dynamically and their opinions on such systems.

These questions are added because without understanding their prior gaming experience, it would not be possible to contextualize their response.

3. Difficulty Preference and Perception

Players reflected on their general preference for difficulty settings (e.g., Easy, Medium, Hard) and their reasons.

Specific questions assessed their perception of the game's difficulty:

- Was the difficulty appropriate for their skill level?
- Were there noticeable changes in difficulty during gameplay?
- Did they feel the DDA system was adjusting difficulty to match their performance, and how did this affect their experience?

These questions directly analyze the player's experience with the designed difficulty system and its impact on engagement.

4. Game Mechanics

Participants provided feedback on the intuitiveness and accessibility of core mechanics, including:

- Aiming, shooting, and resource management.
- Ease of learning and familiarity with the mechanics.
- Open-ended responses captured suggestions for improving gameplay mechanics.

These questions aim to analyze whether the game mechanics were intuitive or difficult to cope with. Areas for improvement in game mechanics were also identified from these questions.

5. Game Design and Environment

The forms explored player opinions on the game's design elements:

- Visual and auditory quality (e.g., graphics, sound effects, background music).
- Level progression and overall design of handcrafted levels.

Participants were asked to report any technical or environmental issues encountered during gameplay. These questions analyze the overall design quality and technical functionality.

6. Overall Feedback

Players shared their overall experience with the game, including:

- The number of levels they completed, and their motivation to keep playing.
- Favorite and least favorite aspects of the game.
- Suggestions for changes or additions to enhance the game experience.

The combination of observational data and feedback forms makes sure that multiple aspects of players' experience during the gameplay are recorded.

3.4 Data Analysis

The analysis of the qualitative data aims to explore whether rule-based DDA works in a level-based artillery game. It also aims to explore the effectiveness in keeping the difficulty level adjusted to player skills.

3.4.1 Analysis Methodology

To analyze the feedback collected through the forms, a combination of coding and thematic analysis was used. The purpose of coding is to find patterns in their responses. The thematic analysis gives insight into players' experiences.

The responses from the forms were coded. Each response was reviewed to identify recurring themes and patterns, like perceptions of difficulty, engagement with mechanics, and overall satisfaction.

Key steps in the analysis included:

1. **Familiarization:** Reading all responses to get an understanding of participant feedback.
2. **Coding:** Assigning labels (codes) to meaningful segments of text (e.g., "noticed difficulty adjustments", "high spike in difficulty").
3. **Theme Identification:** Grouping similar codes into broader themes, such as "difficulty perception" and "mechanics intuitiveness."
4. **Theme Refinement:** Ensuring themes represent the data and align with research objectives.

3.4.2 Identified Themes

After familiarizing myself with the code, I identified the common patterns. The analysis revealed some recurring themes and insights, which are summarized below:

Difficulty Perception

Two players found the difficulty appropriate for their skill level. Two players found the difficulty initially easy and became difficult later. Two players thought the game way easy to play, while the other two thought it is “not too easy”. Notable observations included:

- **Challenge Appreciation:** Some participants, like player one and player three, noticed jumps in difficulty in later levels and appreciated the added challenge. Player three commented, "In the end, the game became significantly more difficult. But I liked that."
- **Gradual Adjustment:** None of the players noticed any sharp rise in difficulty which could make them uncomfortable. Three of the players understood the rise in difficulty but liked it.
- **DDA Awareness:** Out of eight, three players noticed DDA mechanism. However, they all expressed positive feelings about the adjustment.

Intuitiveness of Mechanics

The aiming and shooting mechanics were generally well-received but highlighted a need for better onboarding:

- **Early Learning Curve:** The seventh participant mentioned struggling with the mechanics at first.
- **Suggestions for Tutorials:** The seventh participant also suggested adding a tutorial to help players adjust to the mechanics more easily.
- **Simplistic Mechanics:** Player two, felt the mechanics were overly simplistic, with stating, "The aiming should be more challenging."

Player Satisfaction and Engagement

Players reported high levels of engagement, driven by curiosity and the increasing challenges in later levels:

- **Curiosity as Motivation:** Participants like player three and player five expressed a desire to continue playing to see what new enemies or challenges awaited them. Player three said, "I wanted to see what new enemies were coming."

- **Desire for More Challenge:** A lot of players expressed the need for more challenge. Especially in the beginning, regular players thought the game was too simple. Player two thought the mechanics should be more complicated. This person stated that-
”The targeting system should be more difficult.”

Game Design and Environment

The visual and auditory elements of the game received positive feedback, with player three describing them as clear and consistent. Player three thought the tower stood out a bit more, “ the tower itself seemed to be simpler in style than other assets, making it stand out a bit.”

Suggestions for Improvement

Participants proposed several improvements to enhance the game experience:

- **Enemy Variation:** A recurring suggestion was to include enemies with varying speeds and behaviors to increase the challenge.
- **Mechanic Enhancements:** Players recommended adding tutorials for mechanics and making the aiming system more challenging.
- **Additional Features:** Suggestions included adding power-ups (Player seven) and expanding the number of levels to maintain engagement over time.

3.4.3 Observation

The players were observed during playtesting sessions and recorded the sessions. Following observations were made from these sessions:

Player, one has no issue understanding the mechanics. He made perfect shots in the evaluation phase of the game. The game offered him hard level all the time. In the last two levels, when enemies with multiple life, flying enemies who were shooting at the tower started to come, he found it a bit difficult. He started missing some shots as well. His tower took damage, but he did not fail any level.

Player two has good performance in first two levels. Then he started missing shots. He failed the later level multiple times but seems to get a hang of it by the end. He has issue with enemies that change direction and enemies that damage the fort from a distance. His fort took a lot of damage. However, after failing a level (level three), he performed well in that level. So, the game offered him hard level, since when he was able to pass the level, he has a good score.

Player three performed very well in the first three levels. After that he started missing shots. He also has trouble killing enemies with multiple lives, failed later level and improved at the end. Like player two, after failing a level several times, he improved and got harder level upon success.

Player four performed well throughout the game. He did miss some shots, and his tower took damage from shooter enemies. But he passed all the levels smoothly.

Player five has trouble in the first level, he missed a lot of shots at the beginning. However, he improved after level two. It is possible that this player had trouble understanding the shooting mechanism. He also struggles once the game started spawning hard enemies.

Player six has no problem understanding the shooting mechanism and performed well. He seems to get bored a little bit; the hard level did not seem hard enough for this player.

Player seven seem to have trouble only in later levels with complex enemies. Overall, he played smoothly and had no trouble understanding the mechanics at all.

Player eight had no trouble understanding the mechanics. The player passed the evaluation phase easily but had trouble in the later stages. Good performance in the evaluation phase resulted in the DDA mechanism choosing a hard level. The player struggles with it a bit. However, they seemed motivated to keep trying.

3.5 Results

This section presents the findings from the playtesting sessions, focusing on player feedback and observations about the game. By analyzing participants' reactions, perceptions of difficulty, and their experiences with the game mechanics and design, insights were obtained into the effectiveness of the rule-based Dynamic Difficulty Adjustment (DDA) system. The results are categorized into key themes, including general player reactions, perceptions of the DDA system, learning curve and complexity, feedback on game design, and skepticism or discomfort. These findings highlight both the strengths and areas for improvement in the game's design and the adaptive system that was implemented.

4.4.1 General Player Reaction

Participants generally responded positively to the game, describing the experience as engaging and addictive. The visuals and sound design were widely appreciated, with players highlighting the polished graphics and immersive sound effects as key contributors to their

enjoyment. One player said their first thought about the game was, “Good visuals and the sounds”.

While most participants enjoyed the game, some noted that the aiming mechanics were initially challenging to understand. As one player mentioned, “The game mechanics were initially difficult to understand.” Others commented on the early levels being too easy but acknowledged that the challenge improved as the game progressed. For example, one participant stated, “Too easy at first, but it got interesting after the first level.” It is worth mentioning that, since at the beginning (evaluation phase) the game does not know the players skill level, it offers everyone a simple level. The difficulty mode is offered once the game has decided about player’s performance. So, this reaction was expected.

4.4.2 Difficulty and DDA Perception

Even though some players said that the game was too easy for them (player two and three), observation from the playtesting session is that they struggled to pass levels after the evaluation phase. They improved after failing and trying the later levels several times. When they improved and passed a level with good score, the game gave them a hard level. This proves, that the simple rule-based system can consider the player’s improvement during the gameplay and make decision accordingly.

Daily Players: Participants like player one, four and seven, found the game generally easy even at its most challenging levels. Mamun noted, “It is all about timing”.

Infrequent Players: One infrequent player, player five mentioned the game is - “simple, but not too easy”. Another person, player eight, found the later level a bit hard. However, this person did not want me to lower difficulty, rather wanted to keep trying.

Not all players were explicitly aware of the DDA system. Most participants who noticed changes in difficulty described them as subtle and appreciated the adjustments. During the University expo, one player mentioned, “There is a high spike in difficulty, Level 5 is too difficult than level 4”. This part was adjusted and refined. In the final testing, no one said the difficulty has a sudden jump.

4.4.3 Game Complexity and Learning

The core mechanics (aiming and shooting) were generally regarded as intuitive once learned. However, two participants suggested adding a tutorial to ease new players into the

gameplay. At least three players talked about confusing mechanics and resource management system.

Player five initially struggled with the mechanics but adapted by the third level. Despite these early challenges, most participants found the mechanics engaging, with one player noting, “It is all about timing.” Player five also mentioned, “It may be possible to find a cheat position for the arrow and shooting”. However, he did not find this spot yet.

Overall, some players will benefit from a tutorial while others did not have any opinion about it. A tutorial with skip option can solve this problem.

4.4.4 Feedback on Game Design and Levels

Most participants did not feel the level progression was uneven or abrupt. However daily players have found like players four and six found all level too easy in general. Player six suggested, “I think, there should be a lot more levels. The level progression was smooth. But it needs to be more difficult.”

However, some participants expressed a desire for more enemy variation. Players like player five recommended increasing the number of levels and adding power-ups, enemy variation along with adding more enemy waves.

4.4.5 Discomfort and Skepticism

Participants came from a mixed background where some of them never heard of DDA and some are highly critical of DDA. Player three mentioned that they don’t believe DDA bring anything new to a game.

Most players did not notice the adjustments made by DDA mechanism. Players who noticed the game was getting significantly harder also mentioned that they enjoyed this increase in difficulty. Overall, the DDA mechanism in this game did not receive any criticism in terms of player experience.

3.6 Discussion of Findings

This section discusses the broader implications of the findings, focusing on the balance between difficulty and player performance as achieved through the rule-based DDA system. The implications for future design improvements are discussed here as well.

4.5.1 Balance Between Difficulty and Player Performance

The findings suggest that the DDA system was mostly effective in determining the player's skill level. For expert players who reached the Hard mode in levels, a variation in enemy movement and bigger enemy wave can give them increased difficulty to match their expertise. But the design of easy and medium modes is mostly alright for infrequent player.

4.5.2 Implication on Future Design

Based on the results, several design improvements can be considered:

Enhanced Tutorials: Introducing a short tutorial or visual cues could help players adapt to the mechanics more quickly.

Increased Enemy Variety: Adding enemies with faster movements or dynamic behaviors would make gameplay more dynamic and engaging.

Additional Features: Power-ups, more levels, and dynamic environmental elements could maintain engagement over longer play sessions.

Mechanics Clarity: Simplifying or better integrating resource management could make it more meaningful to gameplay.

The importance of curiosity (e.g., wanting to see what new enemies appeared) highlights the potential for designing content that continuously surprises and challenges players.

The results indicate that the rule-based DDA system effectively balanced difficulty for most players. It dynamically adapted to their skill levels. However, expert players would benefit from additional challenges, like larger enemy waves or more dynamic behaviors. The study also highlights key opportunities for improvement, including better tutorials, increased enemy variety, and clearer resource management mechanics.

4 Limitations and Further Research

The study presents valuable insights into the use of rule-based Dynamic Difficulty Adjustment (DDA) in an artillery game, but several limitations highlight areas for further exploration and improvement.

Limited Performance Metrics

The DDA algorithm in this study relies solely on player shooting accuracy to adjust difficulty. While this approach is straightforward and effective for this game, it may not account for the diverse range of skills and behaviors that influence the player experience. For example, factors such as reaction time, decision-making speed, or time spent on a level could provide a better understanding of player performance. Future research could explore integrating multiple performance metrics to refine difficulty adjustments.

Increased Designer Workload

The current DDA system requires designers to create maximum three modes for each level, ensuring a range of difficulty options for the algorithm to select. This adds to the designer's workload compared to using a single, fixed-difficulty level. However, if players were required to select their difficulty at the beginning (e.g., Easy, Medium, Hard), these multiple modes would still need to be designed. While DDA ensures adaptive experiences, future work could explore ways to automate level design processes or develop tools to assist designers in generating varied difficulty levels more efficiently.

Genre and Context Specificity

The DDA system and predefined levels in this study were designed specifically for an artillery game. This design may limit the algorithm's applicability to other game genres or gameplay styles. For example, genres with open-world exploration or military-simulation might require entirely different approaches to DDA. Further research could examine whether it is possible to use rule-based DDA in different game contexts and its scalability across various genres.

Controlled Testing Environment

The testing was conducted in a controlled environment, which may not fully reflect real-world gaming conditions. Players might behave differently in natural settings, where distractions, extended play sessions, or limited hardware setups could influence their

experience. Future studies should consider real-world testing to better understand how players interact with the game and perceive difficulty adjustments in less controlled scenarios.

Generalizability of Findings

The relatively small sample size and specific target audience (players familiar with gaming) may limit the generalizability of the results. Future research could involve a larger and more diverse participant pool, including players with varying levels of gaming experience, to ensure broader applicability of the findings.

Conclusions

This thesis presents the development and evaluation of Formidable Fortress, an artillery game that uses a rule-based Dynamic Difficulty Adjustment (DDA) system with predefined rules and difficulty modes. By relying on designer-crafted levels and a simple function based on shooting accuracy, this study explores a novel approach to balancing player challenge and engagement. Unlike procedural content generation (PCG) or complex adaptive algorithms, this method ensures a consistent and high-quality gameplay experience while dynamically adapting to individual player performance.

The study successfully achieved its key objectives:

- Designing and developing the game elements and levels.
- Implementing a DDA mechanism that dynamically adjusts difficulty modes based on player performance.
- Evaluating the system's effectiveness through qualitative feedback and observations from playtesting sessions.

The results indicate that the rule-based DDA system effectively determined players skill level and selected proper difficulty mode for them. This approach highlights the potential of combining straightforward rule-based systems with designer-driven content to enhance player satisfaction.

However, several limitations were identified during the study:

- The reliance on shooting accuracy as the sole performance metric limited the system's ability to account for other important player behaviors, such as reaction time or decision-making.
- The controlled testing environment may not fully reflect real-world gaming conditions, where distractions and varying setups could influence player experiences.
- The need to create multiple difficulty modes for each level places an additional burden on designers, which may affect the scalability of this approach for larger games or smaller development teams. However, if the designer wants to offer the use a choice of difficulty settings, the same workload is expected.

To address these limitations, future research could:

- Consider additional performance metrics, such as time taken to complete levels or decision-making patterns, to refine the DDA mechanism.
- Explore the scalability of rule-based DDA systems in larger projects by developing tools and plugins to help reduce the designer workload.
- Test the game in natural gaming environments to gain insights into real-world player interactions and feedback.
- Investigate the applicability of rule-based DDA systems across different game genres to evaluate their scalability and adaptability.

In summary, the combination of handcrafted levels and a straightforward rule-based DDA system represents a promising avenue for adaptive game design. This study serves as a foundation for future exploration, focusing on the potential of simple rule-based adaptive systems.

Acknowledgements

Firstly, I would like to express my gratitude to Mark Muhhin, my supervisor, for his continuous support, patience, and guidance throughout the journey of this thesis. Their expertise and insights were invaluable to this work.

Special thanks to all participants, whose feedback and suggestions significantly enhanced the quality of this work.

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Appendix

I. Interview Guide

1. First impressions of the game

- a. What were your initial thoughts when you started playing the game?
- b. How did the game make you feel while playing?

2. Previous Gaming Experience

- a. How often do you play video games? And what type of games do you usually play?
- b. Have you played artillery or similar skill-based games before?
- c. Are you familiar with games that adjust difficulty? If so, how do you feel about them?

3. Difficulty Preference

- a. Given the option, which difficulty settings do you choose in games (Easy, Medium, Hard)? Why?
- b. Did the game's difficulty feel appropriate for your skill level?
- c. Did you notice any points where the game became harder or easier?
- d. Did you feel that the game was adjusting its difficulty to match your performance? If yes, how did you feel about it?

4. Game Mechanics

- a. Were the game's mechanics (e.g., aiming, shooting, resource management) easy to understand and use?
- b. Did you find the game mechanics intuitive and familiar? If not, what was confusing or difficult to understand?
- c. Is there anything you would change about the game mechanics to make it more enjoyable or engaging?

5. Game Design and Environment

- a. Did you like the game's visual (e.g., graphics) and auditory elements (e.g., background music, sound)?
- b. How did you feel about the design of the levels and level progression?
- c. Did you encounter any technical or environmental issues while playing?

6. Overall Feedback

- a. How many levels did you complete? Did you feel motivated to keep playing? Why?
- b. What did you like about the game?
- c. What did you dislike about the game?
- d. If you could change one thing about the game, what would it be?

II. Glossary

1. PCG (Procedural Content Generation)- The automated creation of game content, such as levels, maps, or items, using algorithms or predefined rules.
2. DDA (Dynamic Difficulty Adjustment)- A game design technique that dynamically modifies the game's difficulty based on player performance or behaviour to maintain engagement.
3. MDA (Mechanics-Dynamics-Aesthetics)- A framework for understanding game design, where Mechanics refer to rules and systems, Dynamics describe emergent gameplay, and Aesthetics focus on the player's emotional experience.
4. Rule-Based System- A system that uses predefined rules to determine outcomes, such as adjusting game difficulty based on specific player metrics.
5. Player Engagement- The level of interest, attention, and motivation a player experiences while interacting with a game.
7. Flow State- A psychological state where a player is fully immersed in the game, balancing skill and challenge to maintain enjoyment and engagement
8. Qualitative Analysis- A research method focusing on non-numerical data (e.g., player feedback, themes, patterns) to understand experiences and perspectives.
9. Playtesting- The process of having participants interact with a game prototype to gather feedback on its mechanics, difficulty, and overall design.
10. Static Difficulty- A traditional approach where players select a fixed difficulty level (e.g., Easy, Medium, Hard) at the start of the game.
11. Player Performance Metric- A measurable factor (e.g., shooting accuracy, completion time) used to assess a player's skill or behaviour during gameplay.
12. Adaptive Gameplay- A design approach where the game adjusts its elements (e.g., difficulty, pacing) based on player behaviour to enhance engagement.

III. Project Repo

Project is available on Github: <https://github.com/i-euna/MSThesisCode>

IV. Online Game

The game is available in itch.io: <https://euna-ukut.itch.io/formidablefortress>.

V. Audio Resource

The sound effects and background music in Formidable Fortress were downloaded from the royalty-free music site [Pixabay](https://pixabay.com). All assets are used to comply with the licensing agreements provided by this platform.

VI. Accompanying Files

- A folder with interviews from playtesting sessions.
- A file with coding of player feedback.

VII. Usage of AI Tools

This thesis includes the use of Grammarly and ChatGPT-4 for translating abstracts, writing, and grammar correction up until January 7, 2025.

Grammarly for Thesis Writing Assistance

1. Help in correcting punctuation
2. Help in correcting grammar and spelling.
3. Help with tone adjustment and word choice.
4. Plagiarism check.

ChatGPT-4 for Programming and Using Unity (Figure 17)

1. Help with creating the shooting projectile.
2. Help with creating shader for shooting projectile.
3. Help with creating Unity scriptable objects for the event system.
4. Help with C# language syntax.
5. Help with creating custom data structures with Unity Scriptable Object.

ChatGPT-4 for Thesis Writing Assistance

1. Summarizing research paper.
2. Help with explaining complex academic language.

3. Improve clarity and readability.
4. Format reference following academic standards.
5. Translate the abstract to Estonian.

Impact on Thesis

Both Grammarly and ChatGPT help improve the writing and technical content. The AI support was essential for maintaining both coding and writing quality. The screenshots (Figure 17, Figure 18) below demonstrate some use cases:

The screenshot shows a chat window with the following content:

ChatGPT 4o

How to create custom variable in unity with scriptable objects?

Creating custom variables in Unity using Scriptable Objects is a great way to organize data and make it reusable across multiple game objects or scenes. Scriptable Objects are assets that store data and can be used as custom variables for your game.

Here's a step-by-step guide:

1. Create the Custom Variable Scriptable Object

You need to create a custom ScriptableObject class to define your variable type. Here's an example of creating a custom variable for storing an integer value:

```
csharp
using UnityEngine;

[CreateAssetMenu(fileName = "New Int Variable", menuName = "Custom Variables/Int Variable")]
public class IntVariable : ScriptableObject
{
    public int Value;

    // Optional: Add methods to manipulate the value if needed
    public void SetValue(int newValue)
    {
        Value = newValue;
    }
}
```

Figure 17. Coding assistance from ChatGPT.

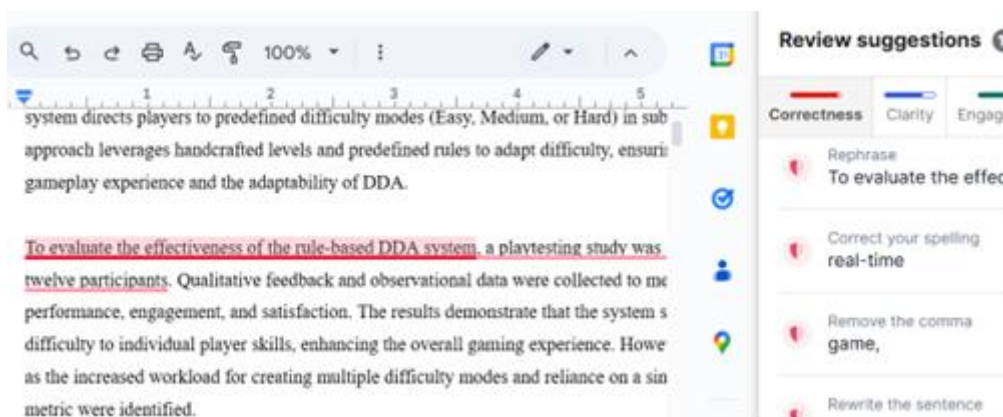


Figure 18. Writing assistance from Grammarly.

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