Bachelor Project

Czech Technical University in Prague

F3

Faculty of Electrical Engineering
Department of Computer Graphics and Interaction

Evaluating Players Performance in Strategic Games

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Supervisor: doc. Ing. Jiří Bittner, Ph.D.
January 2022

ZADÁNÍ BAKALÁŘSKÉ PRÁCE

I. OSOBNÍ A STUDIJNÍ ÚDAJE

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Zadávající katedra/ústav: **Katedra počítačové grafiky a interakce**

Studijní program: **Otevřená informatika**

Specializace: **Počítačové hry a grafika**

II. ÚDAJE K BAKALÁŘSKÉ PRÁCI

Název bakalářské práce:

Hodnocení výkonu hráče ve strategických hrách

Název bakalářské práce anglicky:

Evaluating Players Performance in Strategic Games

Pokyny pro vypracování:

Zmapujte existující metodiky pro hodnocení výkonu hráče a jím realizovaných akcí během hry. Soustřeďte se na strategické hry, konkrétně žánr automatických soubojových her (Auto Battle). Podrobně rozeberte metodiky hodnocení hráčů používané v tomto herním žánru.
Navrhněte metodiku hodnocení akcí hráče v Auto Battle hrách, která umožní poskytnout podrobnou zpětnou vazbu o akcích hráče během hry a po jejím skončení. Soustřeďte se i na způsob porovnání akcí v různých hrách (partiích) a srozumitelnou prezentaci tohoto porovnání ve vizuální podobě.
Navrženou metodiku a nástroje pro porovnání herních výkonů hráčů implementujte ve vlastní jednoduché Auto Battle hře. Implementaci průběžně testujte pomocí uživatelských testů a iterativně vylepšujte navržené nástroje. Výslednou implementaci podrobte testování s nejméně třemi různými hráči a shromážděte zpětnou vazbu pomocí dotazníků případně rozhovorů.

Seznam doporučené literatury:

[1] Jesse Schell. The Art of Game Design: A book of lenses. CRC Press, 2008.
[2] Raph Koster. Theory of Fun for Game Design, 2nd edition, O'Reilly Media, 2013.
[3] Simon Egenfeldt-Nielsen, Jonas Heide Smith, Susana Pajares Tosca. Understanding Video Games, 3rd edition. Taylor & Francis, 2016.
[4] Jason Gregory. Game Engine Architecture (3rd edition). CRC Press, 2018.
[5] Michal Pozník. Hodnocení výkonu hráče - metodika a implementace. Bakalářská práce, ČVUT FEL, 2020.
[6] IJsselsteijn, W. A., de Kort, Y. A. W., & Poels, K. The Game Experience Questionnaire. Technische Universiteit Eindhoven. 2013.

Jméno a pracoviště vedoucí(ho) bakalářské práce:

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Jméno a pracoviště druhé(ho) vedoucí(ho) nebo konzultanta(ky) bakalářské práce:

Datum zadání bakalářské práce: **10.02.2022** Termín odevzdání bakalářské práce: **20.05.2022**

Platnost zadání bakalářské práce: **30.09.2023**

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III. PŘEVZETÍ ZADÁNÍ

Studentka bere na vědomí, že je povinna vypracovat bakalářskou práci samostatně, bez cizí pomoci, s výjimkou poskytnutých konzultací. Seznam použité literatury, jiných pramenů a jmen konzultantů je třeba uvést v bakalářské práci.

. _____
Datum převzetí zadání

_____
Podpis studentky

Acknowledgements

I would like to thank the supervisor of this thesis, doc. Ing. Jiří Bittner, Ph.D., for being patient and insightful in our consultations.

I would also like to thank everyone who participated in user testing of this project for their time and feedback.

Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where states otherwise by reference or acknowledgment, the work presented is entirely my own.

In Pilsen, January 13th, 2022

Abstract

In this thesis, I analyze importance of player evaluation and feedback in video games. I examine evaluation in different games and genres. I also describe design and implementation of an auto battle game created for this thesis and results of its user testing.

Keywords: auto battler, skill, evaluation, feedback

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Abstrakt

V této práci rozebírám důležitost hodnocení výkonu hráče a zpětnou vazbu ve videohrách. Prozkoumávám hodnocení výkonu v různých hrách a žánrech. Také popisuji design a implementaci auto battle hry, která byla vytvořena pro tuto bakalářskou práci, a výsledky jejího uživatelského testování.

Klíčová slova: auto battler, výkon, hodnocení, zpětná vazba

Překlad názvu: Hodnocení výkonu hráče ve strategických hrách

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Chapter 1

Introduction

Games have been played by humans for ages and video games are just the most recent shape they have taken. They are a "problem-solving activity, approached with a playful attitude", according to Jesse Schell, the author of the book The Art of Game Design[2]. They give the player a set of rules and an obstacle and it's up to the player to decide, which way they deal with it. After defeating that obstacle, player gets a reward, that can be as simple as the ability to progress further into the game. But there has to be a reward and the progress has to be measured, otherwise there would be no satisfaction of playing. That is what I call player evaluation and what I am focusing on in this thesis.

1.1 Focus of this thesis

This thesis I examine player evaluation from different points of view. First, I explain why evaluation is important in general and then showcase it in two different games with a quick look into esports. Then I describe the auto battle genre more in depth since it is important for the implementation part of this thesis. I talk about its general concepts and strategies with examples from specific games.

For the implementation part, I developed a simple auto battle game with numerous types of player evaluation and feedback. I describe in detail how the game works from the design point of view in the Design chapter and some interesting technical parts in the Implementation chapter.

This project was tested by several respondents, and I received their feedback in verbal form and through questionnaires. The result is summarized in the Testing chapter.

1.2 Why is evaluation important?

Evaluation is a form of measuring player's progress and success. It is valuable for both game developers and players. Data obtained from hundreds of playthroughs give developers a good opportunity to see their game from the player point of view [1]. In competitive games that are constantly being

updated are win rates important for balance changes, pick rates show, how entertaining certain champion is for the community etc.

For players, feedback is what provides gratification which keeps them motivated to play. When they don't see any results of their actions, they might enjoy it less [2]. There are two types of gratification. Instant gratification is when player is rewarded shortly (or even immediately) after action, it is very common in competitive video games [3]. Delayed gratification has to be achieved through multiple actions and is often harder to get but should feel more rewarding. Delayed gratification is typical for JRPGs (Japanese RPG), where players have to spend hours mastering their skill to be able to progress [4].

Player evaluation can be side-lined only in specific cases, where the strongest motivator lies somewhere else, usually in storytelling. However, even these games often provide some kind of skill check [5].

Evaluation also should help player get better at the game and encourage them to try different strategies. It makes the learning process faster and more meaningful and helps remove the frustration that occurs when player keeps losing without knowing what they are doing wrong.

Chapter 2
Evaluation analysis

In this chapter, I describe evaluation techniques in two prominent games. I want to showcase, how the the methods and measured data differ in various game genres.

2.1 League of Legends

League of Legends is a MOBA (multiplayer online battle arena) with two teams consisting of 5 players each [6]. Each of these players picks a different champion at the start of the game and then work together to destroy enemy nexus.

There are three lines, and a jungle as you can see if figure 2.1. One player goes to the top lane (toplaner), one to the middle lane (midlaner), two to the bottom lane (adc and support) and one roams around the jungle (jungler). There are generally three phases of the game. First is laning phase that takes about 10 to 15 minutes [7]. In that time, all laners farm creeps (neutral units that come in waves) and fight against their counterparts from the opposing team. The jungler farms neutral monsters in the jungle and possibly helps the laners get advantage. Supports can move around the map too, helping other lanes but leaving their adc more vulnerable.

The other two phases are midgame and lategame. Playstyle in those two phases is less defined and the further analysis does not require its detailed knowledge.

2.1.1 In-game statistics

There are many ways to determine, how the player is doing in the current match. The most visible one is KDA, which is calculated as $\frac{kills+assistances}{deaths}$ [8]. It can be a good indicator of how aggressive the player can be without dying. However, not every role and champion are expected to have a high KDA, since their role in the team is not killing enemy players. They can build advantage in a more controlled way.

Indicators of these advantages are gold and level from the player and these two numbers are often showcased through one different statistic – CS (creep

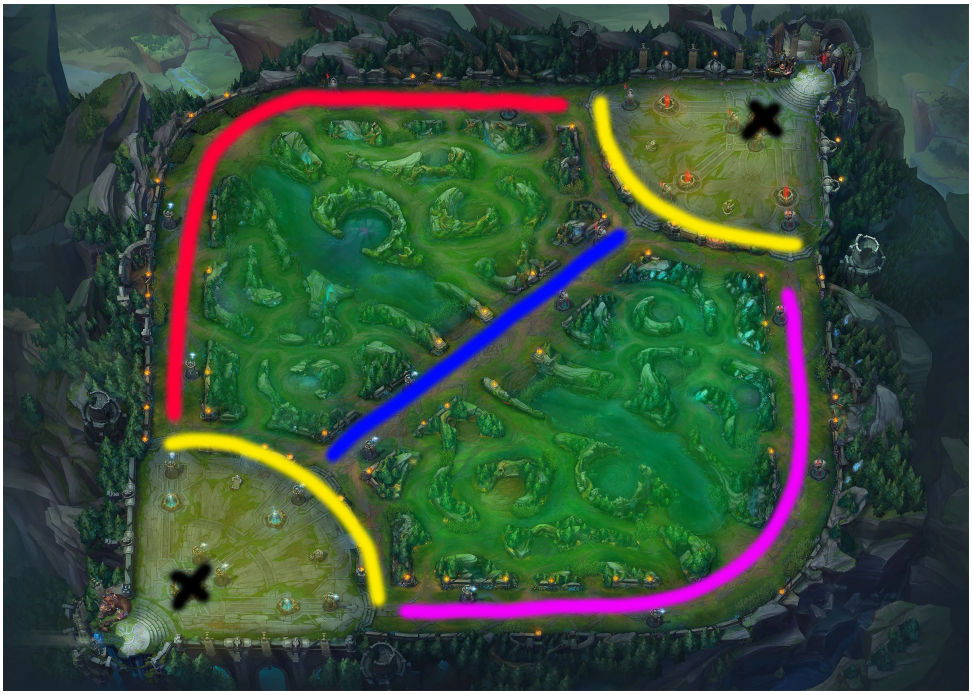

Figure 2.1: Top lane is highlighted with red color, middle lane with blue and bottom lane with pink. Jungle is highlighted with green, base with yellow and nexus with black cross.

score). By killing creeps, player gains both gold and experience, so if they manage to kill more than their opponent, they should be ahead.

Supporting champions are not aiming for high KDA or CS though. Their purpose is to help their carries set up good fights and protect them without requiring many resources. Vision is a big part of that and that is what vision score measures. I couldn't find any official sources explaining how the score is calculated, so I had to rely on the unofficial ones.

There are three factors that impact vision score [9]:

- *Ward lifetime provided.* The player gets up to one point each minute for every live ward they laid. The number of points they get differs according to its effectiveness – wards that don't spot any other than ally units for a long time or wards close to the ally base have lower value. It can even drop to 0 if the ward is close to a friendly structure (turret, base etc.).

- *Ward lifetime denied.* Killing a ward provides 1 point for every minute of remaining lifetime of the ward. That means killing a freshly placed ward gives more points that killing a ward that is running out.

- *Vision mechanics.* There are other ways to grant vision then wards, they can be either champion abilities or specific neutral objects. Each of them grant a specific number of points when used, even if it reveals nothing.

However, if it does reveal enemy champions or epic monsters, player gets up to 1 bonus point.

In professional games, supports should have about 2 vision score per minute, junglers 1.5 and other roles 1 [10].

2.1.2 After-game statistics

After the game ends, players can go through multiple statistics and graphs for every player that participated in the game. The most significant ones revolve around damage and crowd control (CC).

As you can see in figure 2.2, damage is divided into many categories that are self-explanatory. The game offers possibility to visualize all the statistics in graphs which makes it easier for players to compare their performance.

DAMAGE DEALT										
Total Damage to Champions	20,564	49,717	35,679	49,216	42,082	51,388	38,035	11,658	62,986	23,691
Physical Damage to Champions	2,589	30,343	32,530	45,966	1,038	770	30,666	1,461	889	21,215
Magic Damage to Champions	15,865	14,839	3,024	3,250	33,935	48,270	5,215	10,067	59,432	2,104
True Damage to Champions	2,110	4,535	123	0	7,108	2,347	2,154	128	2,664	371
Total Damage Dealt	56,740	150,791	142,407	208,617	124,629	209,488	72,312	15,745	185,941	94,398
Physical Damage Dealt	6,483	108,058	130,073	201,208	5,949	6,127	62,112	1,671	4,738	80,124
Magic Damage Dealt	47,707	33,427	12,210	7,408	93,482	201,013	7,744	13,944	178,338	4,627
True Damage Dealt	2,550	9,305	123	0	25,197	2,347	2,454	128	2,864	9,647
Largest Critical Strike	14	912	1,433	878	0	0	826	0	0	801
Total Damage To Turrets	641	4,784	1,042	2,305	353	676	2,894	424	756	1,226
Total Damage To Objectives	641	4,784	1,042	2,305	353	676	2,894	424	756	1,226
DAMAGE TAKEN AND HEALED										
Damage Healed	7,376	2,716	6,393	5,825	9,629	8,637	967	27,188	8,584	6,966
Damage Taken	62,438	42,081	26,512	40,416	31,565	56,151	31,949	19,469	52,746	44,909
Physical Damage Taken	18,737	14,009	8,534	18,358	10,608	31,838	20,686	13,179	30,240	24,488
Magic Damage Taken	40,665	26,267	17,198	20,549	20,410	19,276	9,032	5,261	19,736	17,607
True Damage Taken	3,035	1,804	779	1,509	547	5,036	2,230	1,027	2,769	2,812
Self Mitigated Damage	97,684	64,492	8,599	29,740	11,322	50,924	21,581	20,654	36,787	38,357

Figure 2.2: Damage statistics from the game for each player.

Crowd control [11] is a term that describes limiting target's control over the game. It contains for example slows (target has decreased movement speed), silence (target cannot cast spells), roots (target cannot move) etc. CC score is calculated from the amount of CC created by the player and is also influenced by the type of the CC [12]. For instance, stun (inability to move and cast) has bigger value than slow.

2.1.3 Esport

In professional League of Legends, there are some other statistics measured apart from the usual ones I mentioned before. They showcase strengths and weaknesses of individual players as well as whole teams.

Meta

Meta is a term describing a tactic that is viewed as currently strong by the community [13]. With every update to the game, the meta changes and whichever team figures it out first has an advantage. Professional meta is most reflected in two statistics.

Pick and ban ratio is a percentage that shows in how many games a certain champion was present. That means it was either picked by one of the players and participated in the game or it was considered too strong and one of the teams banned it (each team has 5 bans at the start of the game; banning a champion means, that nobody can pick it this game).

The other important statistic is winrate. That is percentage of games won with a specific champion. If a player has a big winrate with one champion, the other team might consider banning it even if it does not fit in the current meta.

Players

I chose a few significant statistics that are commonly used in League of Legends esport [14]. Even though statistics cannot truly capture, if the player is talented or not, they can be a strong indicator of their playstyle. You can see an example of team statistics graphic in figure 2.3.

Figure 2.3: Screenshot taken from LEC spring 2022, week 5, match 5: Fnatic vs Vitality. It shows statistics from the last game these two teams played against each other. GD@14 means gold different at 14 minutes, KILL@14 means team kills at 14 minutes, M-LEAD means major lead = time that the team spent with 51.5% or more of the total gold in the game. M-DEFICIT means major deficit = time that the team spent with 48.5% or less of the total gold in the game.

Many of the statistics I will mention are measured only until minute 15 to separate the laning phase.

- CS difference – Shows how well the player can farm by distracting their opponent's CS from their CS.
- Damage per second – Shows how much damage the player dealt each second in average.
- Gold difference – Gold difference between the two teams is one of the best indicators of how the game is going. However, the later in the game it is, the least significance this statistic has.

- Jungle proximity [15] – This percentage shows how much time has jungler spent near the player. It captures, how much help the player has from their teammate.
- Kill participation – Calculated as $\frac{kills+assistances}{teamkills}$*100%. High kill participation means, that the player is very active on the map and significantly helps their team get kills.

2.2 The Witcher 3

The Witcher 3 is a classical role playing game (RPG). RPGs revolve around improving the player character by gaining experience, skill points etc. These values can be seen as a player evaluation since they put the time spent in the game into numbers.

2.2.1 Player level

Player persistently gains experience points (XP) for actively spending time in the game – killing enemies, finishing quests etc. When they earn enough XP, they gain a level. That gives the player a sense of progression and helps game designers control the flow of the game [16].

The progression is best visualized by "numbers" getting bigger [17]. For example, the player has more damage, which means they can easily kill enemies they struggled with a few levels back. They need more XP to reach next level but also gain more XP. That is visualized in a leveling curve. The graph 2.4 is a leveling curve from The Witcher 3 game.

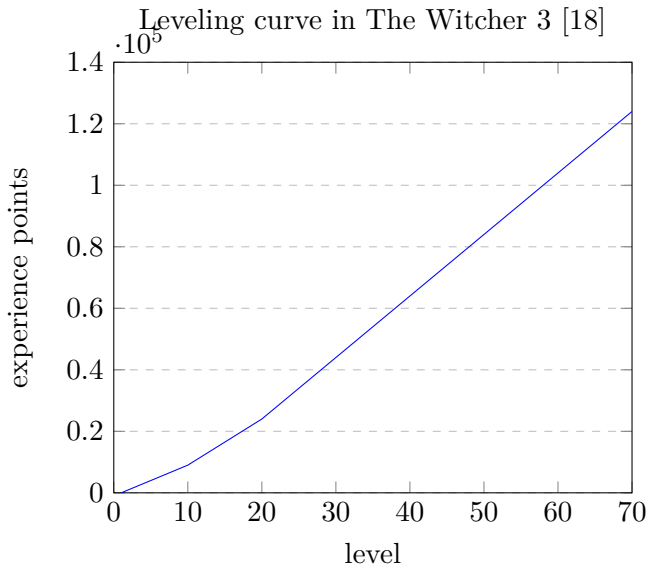

Figure 2.4: This graph shows leveling curve in The Witcher 3. As you can see, it is a constant from level 20 further.

Of course, the environment has to scale along with the player. That is why the location which are supposed to be approached later in the story have enemies and loot with higher levels. There are two possible scenarios where players could exploit this system. They either spend too much time doing side quests and killing monsters which means they reach high levels too soon, or they complete quests intended for much later levels which means they get too strong rewards (e. g. a sword that could kill all the enemies with same level as player with two hits).

There are a few simple ways The Witcher 3 makes these exploits impossible. Players gets only 5% of the original XP for completing a quest (or killing a monster) that is 6 or more levels below the player level. On the contrary, if player fights an enemy that is 6 or more levels above the player level, the enemy gets health and damage buff, making it difficult and time consuming to kill. Also, all items in the game have levels, so the players cannot equip the strong gear if they find it too early in the game.

Chapter 3

Auto Battle Games

Auto battler is a strategy game based on recruiting units to an army [19]. There is a board, on which the player positions their army, and a bench, where they can store units for later use. There is a more detailed description in figure 3.1. Player armies battle each other in several rounds [20]. With every loss, the player is dealt a certain amount of damage. If they lose all their health points, game ends for them. The winner is the one who stays alive last [21].

Figure 3.1: TFT: Both board and bench have limited space. Champions on the board participate in the fight. Champions on the bench are usually bought for later levels or for leveling of units.

3.1 History

The identifying piece for this genre was a custom mod for Dota 2 called Dota Auto Chess made by Drodo Studio. Thanks to its popularity [22], Riot Games made their own version in 2019 [23]. Later that year, both Drodo Studio and Valve created their own versions of the mod, called Auto Chess [24] and

Dota Underlords [25]. In November 2019, Blizzard studios also joined in with their new mode for Heartstone: Battlegrounds [26]. Autobattlers have now slowed down from their early popularity rush, but are still being played by many people [27]. The matches are short and they don't require full focus, which makes them perfect for the currently rising gaming platform - mobile phones [28].

3.2 Gold

Gold is the main part of the genre, because it adds strategy and complexity to the game [29]. It is one of the few aspects, that does not revolve around chances.

Figure 3.2: TFT: On the top of the shop menu you can see the amount of player's current gold. On the right side, there are win and loss streaks. On the left side, players can purchase XP or reroll.

3.2.1 Gaining gold

This is a number of ways how gold is earned in common auto battlers [30, 31, 32]. In table 3.1, you can see specific gains in different games.

- base income – Each player gains a given amount of gold at the start of each round.
- wins – After an army wins, the player gets a small amount of gold at the end of the round. That is important, because it counts into the interest at the start of the next round. Only wins against other players count as a win.
- win and lose streaks – If a player manages to achieve several wins in a row, the game rewards them each round until their win streak ends. The same goes for lose streaks which are very important for comebacks [33].
- interest – At the start of each round, each player gets a certain amount of gold calculated from gold they already have. Usually, it's 10% of their current gold rounded down. There is a ceiling to gold that can be gained in one round from interest to prevent gold stacking.

	TFT	Auto Chess	Underlords	My project
base income	5	5	5	3
win	1	1	1	1
win streaks	1/2/3	1/2/3	1/2/3/4	-
max interest	5	4	3	5

Table 3.1: Comparison of gold gained from base income, winning, win streaks and interest in different auto battle games.

	TFT	Auto Chess	Underlords	My project
1 XP cost	1	1.25	1	1.25
units	1/2/3/4/5	1/2/3/4/5	1/2/3/4/5	1/2/3
rerolling	2	2	2	2

Table 3.2: Comparison of gold costs of experience points, units and rerolling in different auto battle games.

3.2.2 Spending gold

This is a number of ways how gold can be spent in regular auto battlers [30, 31, 32]. In table 3.2, you can see specific costs in different games.

- buying XP – Players can buy experience to level up faster. The cost is around 1 gold per experience point, but XP can be purchased only in predetermined amounts, e. g. player must pay 4 gold for 4 XP, even if they needed only 2 XP to reach the next level.
- units – Every unit has a predetermined cost which ties directly to its rareness. Selling champions returns some of the gold, but not always the same amount that they cost.
- rerolling – Players can manually refresh the shop for a certain amount of gold.

3.3 Experience

By gaining enough experience [34], player level is increased. The level determines, how many heroes player can place on the board and it changes their rolling chances. The higher the level, the more experience is needed to achieve it.

Players gain base number of XP each round and if they want to level faster, they can purchase XP with gold.

3.4 Damage

The damage dealt to a player after loss is calculated as base damage + f(surviving units) [35]. The formula for calculating damage from units varies in

different games. Base damage changes according to the stage of the game [36], it slowly increases to heighten the importance of late losses. For example, in Dota Underlords, the damage from each surviving unit is calculated as 1 + floor(power level / 3). Power level is determined by unit's number of stars and rarity, so the damage from e. g. 2-star Alchemist (tier 3 rarity) is 1 + floor(5 / 3) = 2.

3.5 Units

This is the only part where auto battle games truly differ. Auto battlers usually take champions known from other games from the same company [37] and tweak their abilities so that they suit the genre.

- abilities – Every unit has a unique ability [38], that they usually cast once they fill their mana bar. Mana is gained by taking or doing damage [39].

Figure 3.3: TFT: Ability of one of the units. The numbers for damage and stun duration descirbe values for this unit with level 1/2/3.

- traits – Units have two or more traits [40]. If there is a certain number of units with the same trait on the board, it becomes active and provides specific power ups.

Figure 3.4: TFT: All traits present on the board are shown on the screen. They have a colour that visualizes, whether they are active and on what level they are. The numbers under them show, how many units with this trait player needs to activate the next level of the trait.

- items – In some games, players can equip the units and make them stronger with items. Items have different strengths, so placing them on the correct unit is important [41].

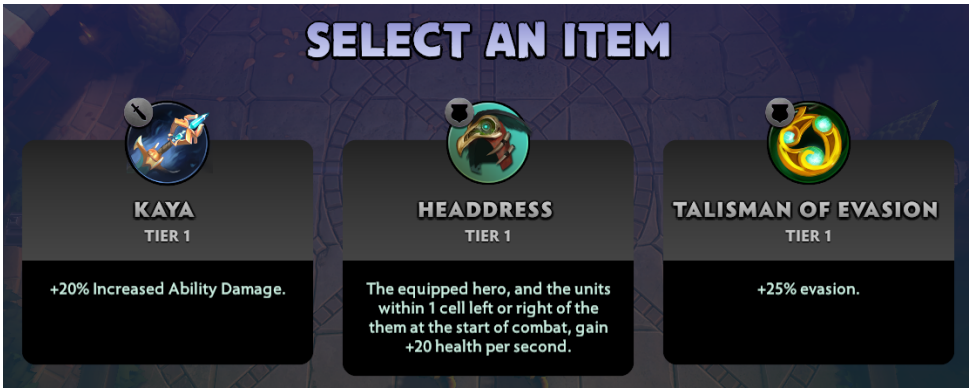

Figure 3.5: Dota Underlords: Every few rounds, players can choose from a selection of items.

- level – If the player buys multiple identical units, they combine into a one with a higher level (visualized by stars). Combining three 1-star units creates a 2-star unit, combining three 2-star units creates a 3-star unit. If player has a 3-star unit, their probability of that unit occuring in the shop drops to 0%.
- cost – Unit cost defines its rareness, i. e. chance to roll it in a shop. Higher cost units are usually stronger, but it is harder to level them up, because their rolling chances are lower.

Figure 3.6: TFT: Difference of rolling chances for player level 4 and 7. Grey color symbolizes 1-cost units, green 2-cost, blue 3-cost, violet 4-cost and gold 5-cost.

3.6 Ranking

MMR [42] is an abbreviation for Matchmaking Ranking. This number determines player's skill and is used to find them as equal opponents as possible. It increases with every win and decreases with losses.

3.6.1 Teamfight Tactics

In Teamfight Tactics, similarly to other games from Riot Games, MMR is hidden from the public [43]. Instead, players can see LP (= league points)

and divisions as you can see if figure 3.7.

Figure 3.7: TFT: This is what players see after a ranked game. Numbers on top are lost LP, number in middle is remaining LP and on the bottom, there is player's division and subdivision, in this case the division is Gold and subdivision is Gold 2.

At the start of every season, MMR of all players is soft reset, meaning it is pulled closer to the median [44]. Then, the first five games they play have increased LP and no LP loss. After those five games, player gets placed in a division.

There are 9 divisions in TFT, the first six are separated into 5 subdivisions. After gaining 100 LP or more, player is promoted to the higher division or subdivision, and after losing while having 0 LP and low MMR, they are demoted. Players gain LP by placing in top four in a ranked game. By placing in bottom four, they cannot gain LP, but they do not have to necessarily lose any either. The amount of LP gained or lost differs according to player's MMR and standing in the game.

To keep only the best players in the three top ranks, there is a decay in Teamfight Tactics. Players can bank up to 10 games and one banked game is removed every day. If they have no banked games, they lose 250 LP.

3.6.2 Dota Underlords

At the start of every season, all ranks are fully reset. New players have to play at least 5 normal games first to unlock the ranked games [45].

There are 9 ranks in Dota Underlords, the first 8 are divided into 5 minor ranks. By placing in games, players gain a certain amount of MMR points, that you can see in figure 3.8.

When getting enough MMR, the player is promoted to a higher rank. With each promotion to a minor rank, they gain minor rank bonus MMR. Also, players cannot be demoted from a major rank when they reach it [46]. For example after they are promoted to Lieutenant, the lowest rank they can be demoted to is Lieutenant I, which is the lowest minor rank in the Lieutenant major rank.

Players in the highest rank are added to the Underlords Leaderboard [47]. However, only those who played at least 5 ranked games in the last 5 days will be visible on the leaderboard.

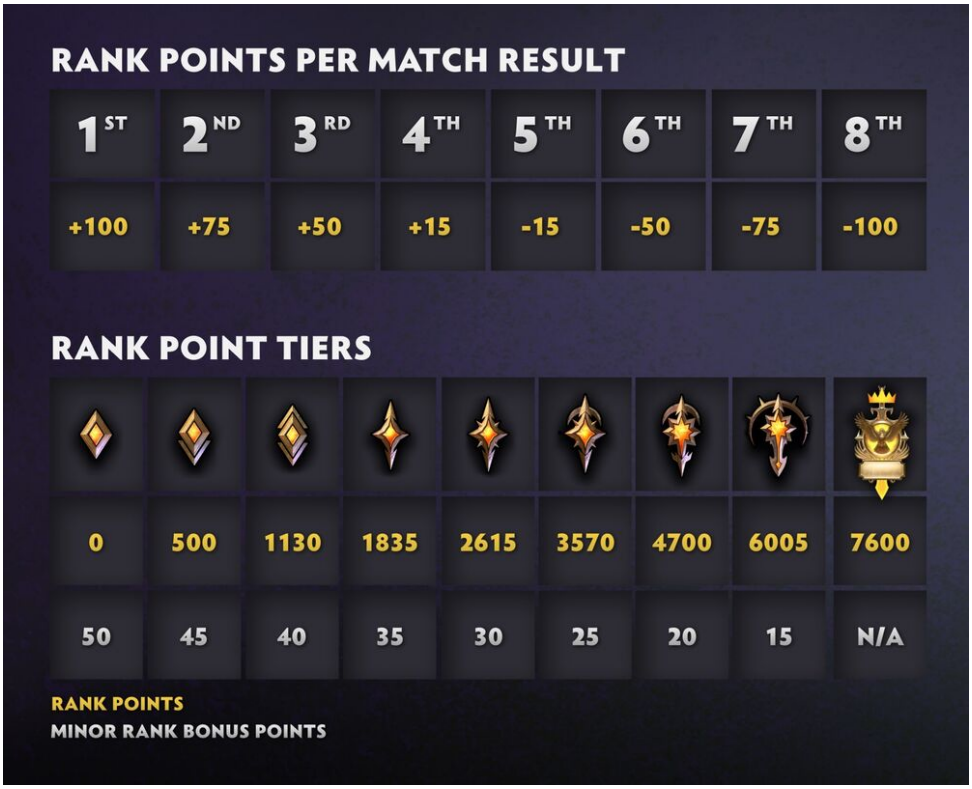

Figure 3.8: Dota Underlords: In the top table, there is amount of MMR players gain for their standing in a ranked game. In the bottom table, there are values of MMR needed to reach a certain rank and minor ranks bonus points.

3.6.3 Other games

Majority of other ranking systems are a mixture of the ones described above. In Heartstone Battlegrounds, there is a dual ranking system [48], meaning there is a hidden ranking used for matchmaking and a ranking visible for players. Auto Chess ranking system is very similar to the one in Dota Underlords [49].

Chapter 4

Design of the project

In this chapter, I describe how the project created for this thesis is designed. I talk about the elements of the game itself like pawn classes, synergies etc. and also about the statistics, that are shown to the player.

4.1 Game

The game itself will be built on the same basis that were described in previous chapter. There are 8 unit classes and four synergies. Every fifth round, player will pick one of three randomly offered items.

4.1.1 Damage

There are three types of damage. Physical damage, that can be mitigated by armor, magical damage mitigated by resistance and true damage, that ignores both armor and resistance of the target. Damage is dealt through auto attacks and special abilities. The actual damage dealt is calculated as physical damage * $\frac{100}{100+armor}$ + magic damage * $\frac{100}{100+resistance}$ + true damage.

4.1.2 Units

- Auto attacks – Units deal auto attacks as soon as they choose a target and move into range. From every auto attack, they gain a certain amount of mana. The number of auto attacks a pawn can produce per second is calculated as (100 + attack speed) / 100. In the table 4.1, there are auto attack statistics for each class. First value always stands for one star, second for two stars and third for three stars.

- Abilities – Each unit needs to gain 100 mana to use their special ability. Using that ability happens automatically and consumes all the available mana. If the special ability is continuous, mana cannot be gained, until that ability stops. In game, ability use is highlighted by change of color as shown in figure 4.1.

  Here are descriptions of special abilities of each pawn and their values. The three values again stand for 1 star, 2 star and 3 star version of the

	Assassin	Commander	Crossbow	King
Physical Damage	65/75/85	25/25/30	80/85/88	45/60/60
Magic Damage	10/10/10	20/25/25	2/4/5	5/10/20
True Damage	0/0/0	0/0/0	3/3/3	0/0/0
Attack Speed	20/30/40	8/8/8	30/38/45	10/12/15
Mana per Attack	6/6/6	11/11/12	6/7/8	8/10/12
Range	1	1	4	1

	Linda	Mace	Swordsman	Teeny
Physical Damage	5/5/7	34/35/41	100/110/120	7/9/11
Magic Damage	30/35/38	6/10/14	0/0/0	28/36/39
True Damage	0/0/0	0/0/0	0/0/0	0/0/0
Attack Speed	5/5/5	1/1/1	7/9/11	3/5/7
Mana per Attack	5/6/7	7/8/9	11/11/11	13/13/13
Range	3	1	1	2

Table 4.1: Damage, attack speed, mana gained per attack and range of all unit classes in the project.

pawn.

- Assassin - Deals 500/550/600 physical and 500/550/600 magical damage to an enemy pawn with most damage dealt so far this round. Indicated by red color on attacked enemy.
- Commander - Lowers mana regeneration and mana per attack to 85/70/55% of all enemies in range 1/2/3 tiles for 3 seconds. Indicated by violet mana bars on affected enemies.
- Crossbow - Crossbows auto attacks gain bonus 8/12/16 physical damage, 2/3/4 magical damage and 5/8/10 attack speed for 3/4/4 seconds. Indicated by orange color of Crossbow's weapon.
- King - Buffs physical and magical damage to 120%, armour and resistance to 100/130/130% and mana regeneration to 100/100/150% to all allies in range 1/2/3 tiles for 3 seconds. Indicated by yellow mana bars on affected allies.
- Linda - Deals 450/520/600 magic damage to the target it's auto attacking and deals half of that damage to all enemies in range 1 around that target. Indicated by blue color on the target and light blue on the surrounding enemies.
- Mace - Heals itself for 10/15/20 health points, gains 1/2/3 armor and resist that stack until the end of the round. Indicated by brown color on Mace.
- Swordsman - Deals 100/120/140 true damage to the target it's auto attacking. Indicated by pink color on the target.
- Teeny - Heals ally with lowest health for 250/400/600 health points. Indicated by green color on the affected ally.

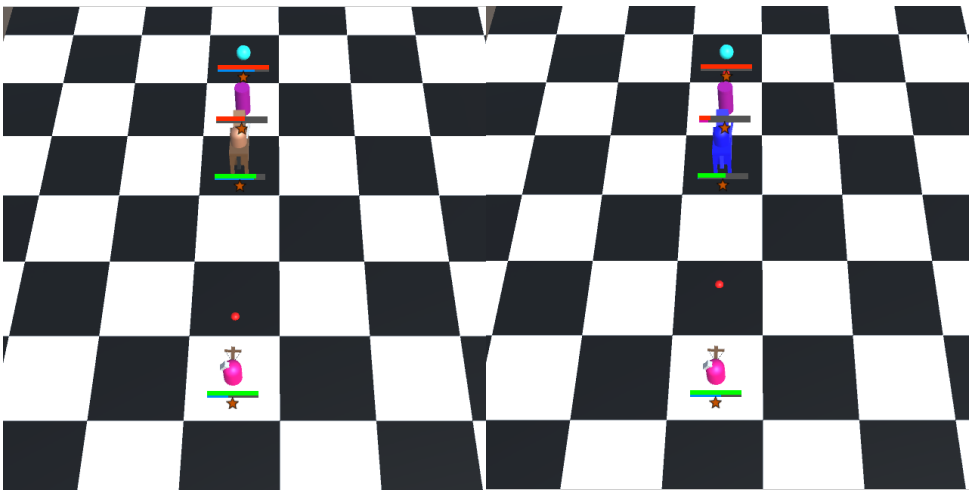

Figure 4.1: When a target is hit by a special ability, it changes color for 0.3 seconds. In this case, commander is being hit by Linda's ability. If the ability is a buff or debuff, the mana bar is colored instead. Each ability has its special colour to be easily recognizable.

- Defensive statistics - Pawns passively gain a certain amount of health and mana every second. In the table 4.2, there are values of mana and health regeneration of each pawn. There are also values of maximum health, that is divided by 100 to fit into the table, and values of armor and resistance.

4.1.3 Synergies

There are four synergies in the game. Each pawn class has 1 to 3 traits that activate those synergies. Each unique active pawn counts into the synergy - that means that having e. g. two Kings on board activates only one Human trait because they are not unique.

Synergies also have levels, only Human synergy has three levels, others have two. First level is activated by two active traits, second by four active traits and third by six active traits. In figure 4.2 you can see, how are synergies visualized in the project.

Description of all synergies:

- Human synergy - Player gains 0.5/0.5/1 gold for each surviving Human unit at the end of each round. This value is rounded down to an integer.
- Orc synergy - All Orc units gain 10/15 passive healing per second. They also gain 3/8 armor and resistance.
- Knight synergy - All buffs from allies and items on Knights are 5/7% stronger. Debuffs are 0/3% weaker.
- Warrior synergy - All damage (physical, magical and true) of Warriors is increased by 10/20 points. Applies to both auto and special attacks.

	Assassin	Commander	Crossbow	King
Mana regeneration	1/2/3	11/11/12	6/7/8	8/10/12
Health regeneration	0/0/0	10/20/30	0/0/0	10/15/20
Maximum health/100	12/14/16	20/25/30	10/11/12	16/19/22
Armor	0/5/10	5/10/15	0/1/2	5/8/10
Resistance	0/5/10	5/15/20	0/1/2	3/5/7

	Linda	Mace	Swordsman	Teeny
Mana regeneration	5/6/7	7/8/9	11/11/11	13/13/13
Health regeneration	0/0/0	15/25/35	5/10/15	5/10/15
Maximum health/100	11/12/13	25/30/35	15/18/21	11/13/15
Armor	0/0/0	10/15/20	3/6/9	2/5/7
Resistance	0/0/0	10/15/20	2/4/6	2/5/7

Table 4.2: Values of mana and health regeneration, starting health, armor and resistance for each unit class in the project.

4.1.4 Items

There are 11 items in the game. The player gets offered three items every fifth round based on their rarity as shown in figure 4.3. When they choose an item, it gets stored in their inventory and they can equip any unit by simply dragging the item icon onto the unit model. Each unit can have only one item and it cannot be removed unless that unit is sold or upgraded.

Here is a list of all items and their abilities:

- Amulet of Mara - Amplifies power of non-attack special ability by 10%.
- Birch Wand - 5% of magic damage dealt to enemies returns as mana.
- Coat of Healing - Amplifies passive healing of the unit by 10%.
- Doran's Ring - Adds 7 points to passive mana regeneration.
- Dwarven Helmet - True damage dealt to the pawn is reduced by 10%.
- Morgul Blade - Attacks ignore 10 armor and resist.
- Precision Arrow - Every auto attack has a chance of dealing bonus 0 - 50% of units physical damage.
- Sunlight Shield - Amplifies armor and resistance by 10%.
- Viper Sword - 5% of true damage damage dealt to enemies returns as health.
- Orc Emblem - Unit gains Orc trait. Cannot be placed on units that already have Orc trait.
- Human Emblem - Unit gains Human trait. Cannot be placed on units that already have Human trait.

Figure 4.2: The filled squares show the number of active units, the highlighted empty squares show number of units with this trait on the bench. When the player places cursor on any of these traits, a little window pops up with description of the synergy and its levels.

4.1.5 Enemy

In my project, the player faces a single opponent. That is not standard for auto battle games, but it should make learning the game easier since player has to continuously adapt to a single play style during the match. The opponent is an algorithm that makes decisions based on simple logic. You can read more about how it works in the Implementation chapter. However, enemy rosters are not preprogrammed, which provides the versatility that is needed to test various scenarios.

4.2 Statistics

4.2.1 In-game statistics

There are some statistics, that are useful during playing. They should lead up immediate changes, that can turn around ongoing match.

Army panel

As you can see in the figure 4.4, there are all active units from player's army on the panel. Their statistics change dynamically while the current round is playing out. They are reset at the beginning of each round, but the player can still go through statistics from last round during the buying phase.

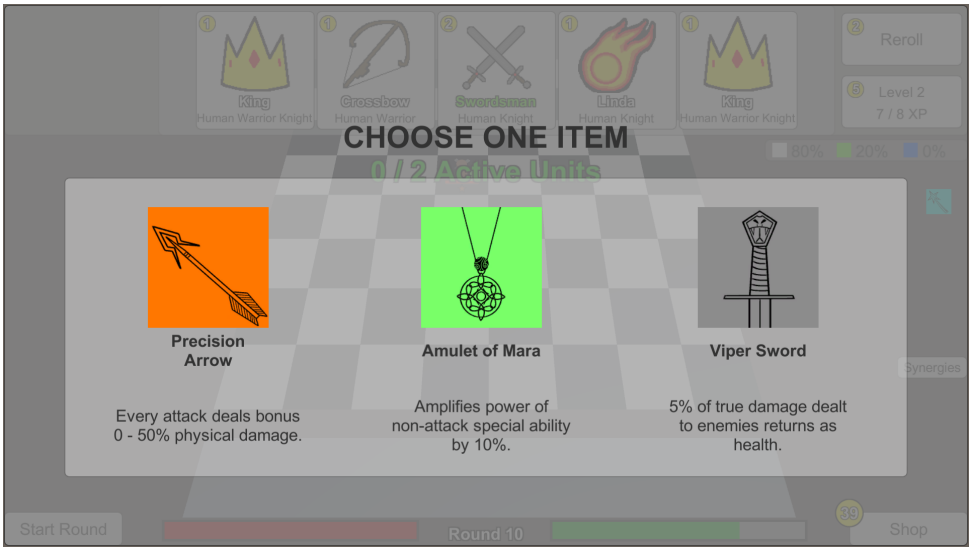

Figure 4.3: Item choice panel.

There are four statistics measured. Damage dealt shows how much damage each pawn dealt to enemy pawns and how much of that damage was blocked. Damage taken shows how much damage the pawn took, but that does not necessarily equal to the health they lost. Damage blocked shows, how much damage the pawn mitigated with their defensive stats and items. Health healed shows, how many health points pawn healed from damage, items etc. See the figure 4.4 for more details.

Figure 4.4: The red bar stands for physical damage, blue for magic damage and pink for true damage. White in damage dealt panel shows, how much damage from the damage dealt was mitigated. In health healed panel, brown stands for healing from damage and green for all other means of healing.

Pawn panels and item statistics

Every panel has its own panel, that can be opened by clicking on it. All the important numbers are shown there along with special attack description and current health. If the pawn has an item equipped, there is a bar that shows statistics specific for that concrete item. See figure 4.5 for details.

Figure 4.5: The pawn statistics change dynamically to show current numbers. Item statistics stack during the whole time a pawn has that item equipped. Since every item has a different purpose, measured statistics differ.

Item statistics help they player to see if they placed the item effectively. For example, if they equip King (that has no true damage) with Viper Sword (that heals from true damage dealt), the item statistic will be zero.

Rolling chances

As you can see in the figure 4.6, there is a small panel under the shop window showing rolling chances for each rarity level. White stands for common units, green for uncommon units and blue for rare units. Shown percentages change dynamically when player levels up. This panel should help the player to recognize when rolling is a good option.

4.2.2 After-game statistics

The game tracks players gold and health management and puts it into a graph. Those graphs can be viewed during the game, but their main goal

Figure 4.6: Rolling chance visualization in the project.

is to summarize the whole match. They should help the player to review their overall tactics and make more long-term changes by comparing different matches.

Economy

Economy statistics will show how the player utilizes their gold. There are several tactics they can follow that revolve around spending [50].

Slow rolling is all about hoarding gold for maximum interest as fast as possible. That usually resolves in weak early game and taking a lot of player damage. With the earned gold, player then can turn the game, but they still try to keep the maximum interest as long as possible.

Hyper rolling means spending all available gold to gain an early advantage. However, rewards from wins are way smaller than money gained from interest, which means the player might soon have trouble not having enough gold for higher cost champions or levels.

Normal rolling is something in between the two approaches above.

The important thing is for player to realize, which approach is the best for the current meta and for their intended team composition. For instance, hyper rolling does not make sense if your team is supposed to have many 4-cost units, because there is a low chance to get them in early levels.

The game tracks three statistics that are described in figures 4.7 and 4.8.

Damage

Each round, the player that lost, takes damage. There can also be a draw if all pawns die at once or if the round takes too long. Damage consists of base damage and pawn damage. Both grow with number of rounds played but pawn damage also changes according to number of units that survived the round. They are visualized by graphs in figure 4.9.

Match history

In menu screen, the player can go through previous matches they played and compare them. As you can see in figure 4.10, each match is visualized by color (red for loss and green for win) and the roster the player had. Each pawn has number of stars and item they had equipped specified under their icon. When clicked, more details about the match show.

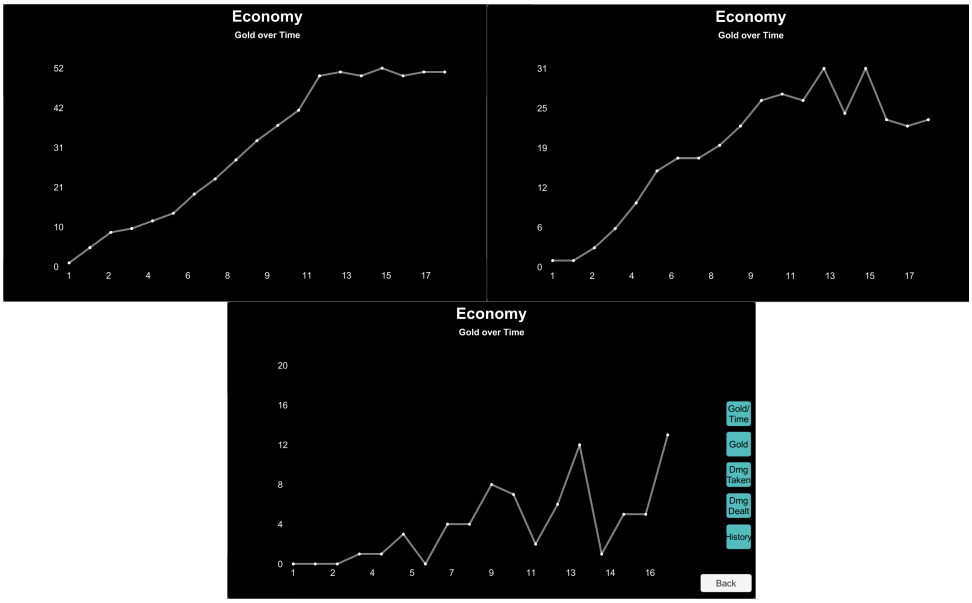

Figure 4.7: This graph shows, how much gold the player had in each round. The first graph would correspond with slow rolling, second with normal rolling and third with hyper rolling.

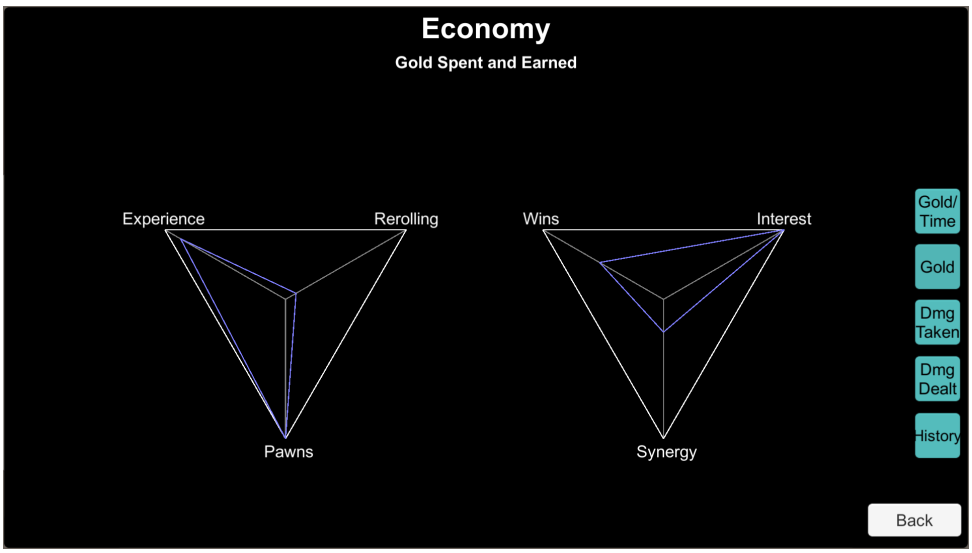

Figure 4.8: These graphs show ratios of gold spent and earned. The first graph shows gold spent on experience, rerolling, and buying pawns. If a pawn is sold, the gold player got back is deducted from the statistic, but player does not always get the full cost back. Second graph shows gold earned from winning (1 gold per win), interest and synergy (Human synergy provides gold for Human pawns surviving).

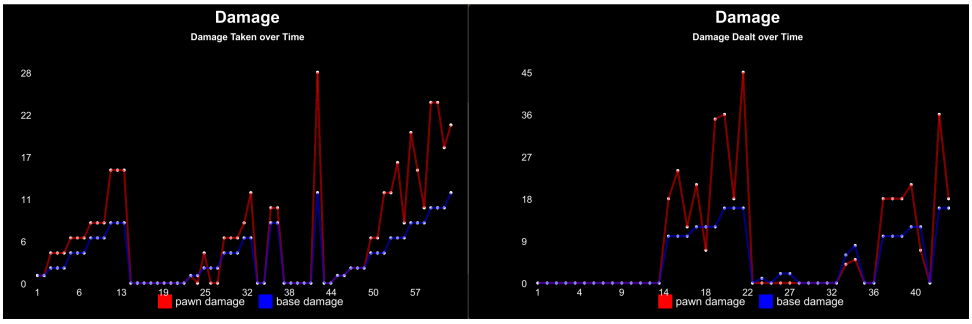

Figure 4.9: The red line tracks base damage, blue line pawn damage. One graph shows damage taken and the other damage dealt in each round. These graphs showcase, how strong player's army was in which game phase.

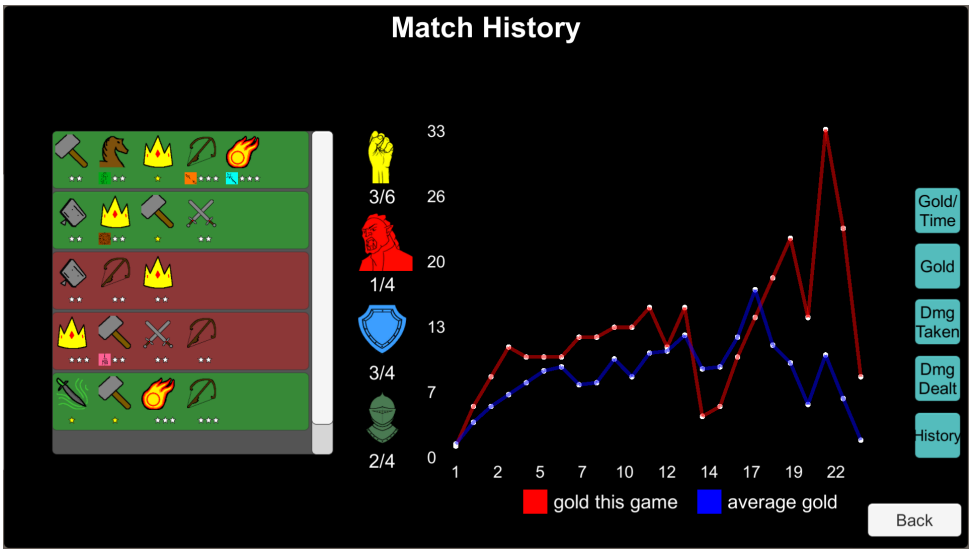

Figure 4.10: On the right side of the panel, there is number of active pawns in each synergy. Next to it, there is a gold over time graph. The red line shows gold the player had in that particular game. The blue line is average gold calculated from all saved games.

Chapter 5

Implementation

In this chapter, I describe some interesting elements of the implementation from the technical point of view.

The game is based on engine for auto battle games that I purchased in Unity Asset Store [51]. It provides the basic setup of board, bench and shop. There are 8 types of units with auto attack scripts and four synergies. I added special abilities of pawns, items, player and enemy health, enemy algorithm and all the statistics that were the main focus of this thesis.

5.1 In-game statistics

Each pawn has an instance of IngameStats script that tracks its statistics (damage dealt, taken etc.).

When combat begins, the StatManager script is called. It first checks if there are any active player pawns on the board and if not, it hides the statistics panel. If there are active player pawns, the panel has to reset first. In destroys all children except one that we keep as a template and resets the IngameStats of all pawns. We also need to keep a list of IngameStats scripts of all the pawns. That is because when the round ends, we want to be able to showcase all statistics of the pawns that participated in the combat even if they are not active anymore (so they are not in the list of active player pawns). We instantiate the template panel for each active pawn and then destroy the template. We reset the scales for each statistic and start the coroutine that refreshes the statistics every 0.1 seconds.

To refresh the statistic we are currently displaying, we go through all the pawns that are on the panel – all active pawns at the start of the combat, but they don't have to be active anymore. First we check, if the sum of values we are supposed to display can fit into the bar with current scale. If not, we have to set a smaller scale (each statistic has its own scale, there is e. g. much more damage than healing and we don't want the bars to be tiny). Then we scale the bars and update the text value. Bars are UI Image components layered on top of each other. To calculate their correct width, we always have to sum widths of all bars on top of the one we are currently changing with the value its supposed to display multiplied by scale.

If a button is clicked to change which statistic is showing, StatManager

updates the title, colors and width of the bars.

5.2 After-game statistics

The Statistics script keeps track of all the statistics showcased in the menu. There are also functions for each button in the menu, that show the graph player selected and hide all other graphs.

5.2.1 Match history

After the game ends, GameManager saves it into JSON file. To do that, it first creates an instance of Roster class. Roster saves all important information about the match in serializable format. There are three lists – first contains names of all active pawns, second their number of stars and third names of their item (or null if the pawn did not have any). When we are loading this data from the JSON file, we convert it back into a Roster instance. Then we need to go through the whole pawn database and find, which icon belongs to the name we saved. The same goes for items.

5.3 Items and pawns

Items and pawns work in a very similar way. There is a class that holds default statistics of the item (ItemStats) and a class that has statistics for a specific item that has its own game object (Item). When player picks an item, new instance of the item prefab is created, and the Item class loads statistics from ItemStats class. If there are any changes to the item, they stored in the Item class.

5.4 Enemy algorithm

5.4.1 Decision making

The enemy has the same conditions as the human player. It gets gold, experience, rolling chances etc. in the same manner. At the beginning of each round, game manager calls method that decides, what the best move is in enemy's current state.

If the enemy army has not reached its full capacity, i. e. the enemy can have more active pawns than it currently has, it investigates the shop for the best purchase it can make. It prioritizes the pawns it does not have yet in its army and the more expensive pawns. If no good purchase is found (shop is empty or enemy does not have enough gold), enemy puts pawns from bench onto the board, if it has any.

If there is any gold left, enemy investigates the shop for the best purchase it can make for combining pawns into stronger ones. The algorithm prioritizes units it already owns. For example, if there are 2 one-star Kings on the enemy

bench and 1 two-star Linda, it will prioritize Linda since a two-star pawn is worth 3 one-star pawns. However, if there was a three-star Linda, which is worth 9 one-star pawns, it would count as 0 since a three-star pawn is the strongest possible combination already.

If a good purchase is found but there is no space on the bench left, algorithm compares the purchase with the weakest pawn it owns. That means if enemy had 2 one-star Crossbows and 1 one-star Assassin, it would sell the Assassin to purchase Crossbow if there was no space left on the bench.

Afterwards, if there is enough gold left, enemy purchases experience. If it has more than 50 gold, it continues purchasing experience if possible since the maximum interest is 5 so there is no reason to keep more than 50 gold. If the experience purchases resulted in a level up, the army size increased, and the algorithm has to check again the best way to put pawns on board.

After every pawn purchase, the algorithm checks if there is enough pawns for an upgrade. If yes, it performs the upgrade and if any of the combined pawns had an item, it places the item on a random different pawn.

5.4.2 Items

Enemy gets offered 3 random items every 5 rounds along with the player. It chooses the item randomly and then iterates through the army (and bench if needed) and places the item on the first pawn that has no item.

5.4.3 Pawn creation and placement

Creating pawns onto the enemy board is the same as when player buys a pawn. The game object is created from prefab and it is assigned to a tile. Enemy bench, however, is invisible to the player. Pawns that go onto the bench are set not active and have no tile.

When a pawn is moved onto the board, algorithm decides, on which tile it should go. It simply searches the best fitting row according to pawn's range from the middle and places it on the first empty tile.

Chapter 6

Testing

6.1 First round of testing

The first round of testing was focused on polishing the game into the final version that could go to the other testers. Since it required a bigger time investment and knowledge about the game, I asked only one of my colleagues to help me with it.

He reported me several bugs, that I did not notice during my own playthroughs. The game was randomly crashing due to never ending loop and the damage graphs threw errors when a pawn was sold.

He also helped me with balancing. It is difficult to make even such a small game balanced, so I had to go through a lot of trial and error. In the end, the Crossbow pawn and human trait were nerfed severely and the Teeny and Linda pawns and orc traits were buffed.

I also added the chance percentage panel (see design chapter) under the shop at his instigation.

6.2 Second round of testing

The questionnaire and answers of individual respondents can be found in the appendix.

For this round of testing, I found 6 respondents who were willing to spend a little time on the game and fill in the questionnaire. I tried to select people with different gaming experiences to cover various points of view.

The questionnaire was separated into three parts. The first one established the age of the respondent and their experience with video games, second contained questions that compared the project with other autobattlers and was visible only to respondents, who had some experience with autobattle games. Third part was focused on usefulness and quality of feedback in the project.

Majority of the respondents were between ages 15 – 25, only one was above that age. All of them had at least minimal experience with video games, half of them claimed to have a broad and active interest in gaming, as you can see in graph 6.1. These experienced gamers were the only people, who had

any experience with autobattlers, which indicates it's a genre that is not the most attractive one for occasional gamers.

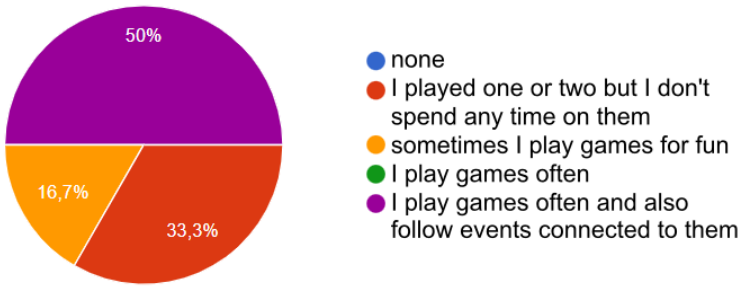

Figure 6.1: What is your experience with video games?

In comparison to other autobattle games, feedback in my project is comparable or slightly worse according to the respondents. However, they would appreciate certain elements from the feedback in my project in other games. Specifically, the after-game statistics (gold and damage graphs), in-game statistics (damage taken/blocked/dealt, health healed of each pawn) and match history, which is depicted in graph 6.2.

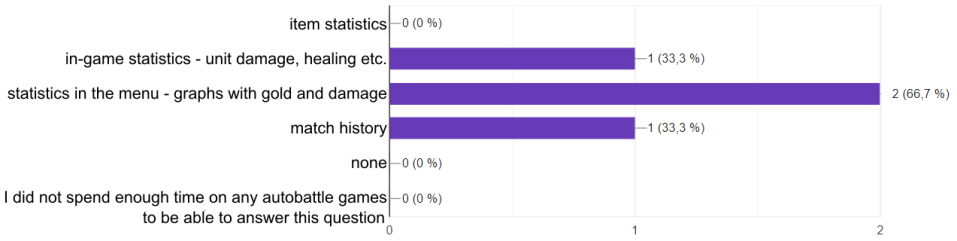

Figure 6.2: Which of these components would you like to see implemented in the game you play/used to play?

In the project, the majority of respondents appreciated the in-game statistics most, as you can see from graph 6.3. Opinions about the least useful statistic were more diverse which is depicted in graph 6.4. Part of the respondents answered that none the statistics were useless, since they can make use of all the information provided. Part of the respondents chose the elements they did not understand or did not see any value in, specifically they named after-game statistics, match history and the reroll chances panel.

All respondents found the feedback useful, which you can see in graph 6.5. The majority claimed it helped to make both specific changes during the match and gradual changes over the course of several matches. They had no ideas on how to improve the feedback or what should be added.

In conclusion, it seems like the feedback in my project covered all the important aspects, but the execution was not always the best. Statistics should be clearer for inexperienced players and the information they provide could be slimmed down to not overwhelm the player. On other hand, the

feedback was helpful for all of the respondents it definitely plays an important part in the game.

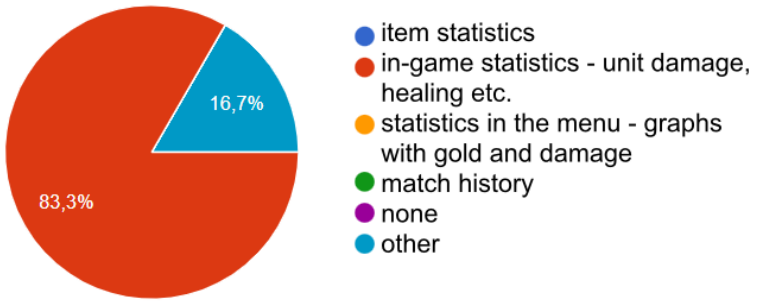

Figure 6.3: Which statistic was the most valuable in your opinion?

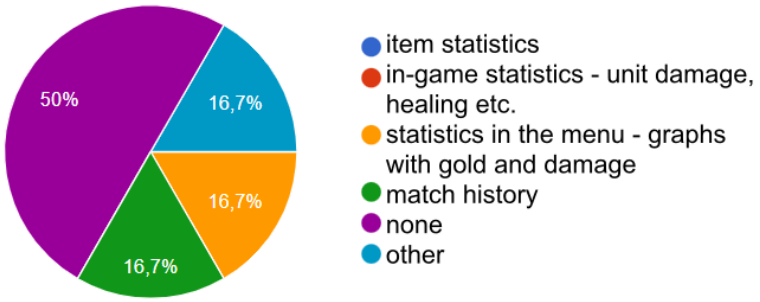

Figure 6.4: Which statistic was the least valuable in your opinion?

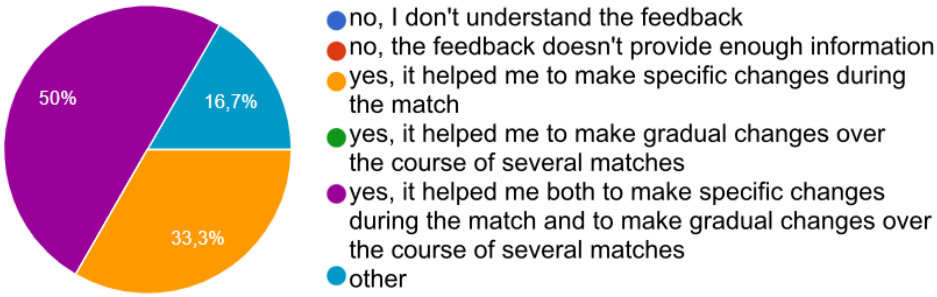

Figure 6.5: Did the feedback in the form of statistics help you to identify, what you can do better in the next match?

Chapter 7

Conclusion

In this thesis, I analyzed evaluation in different game genres. I described concepts of auto battle genre and described design and implementation of my own game from this genre. I tested this game with several respondents to determine quality and usefulness of its player feedback.

The responses showed that the feedback was useful and helped players improve in the game. They appreciated the immediate statistics shown in game the most, statistics summarizing the whole game seemed redundant to some.

There are many ways the game could be improved from the technical point of view. The enemy algorithm is rather trivial, which makes it very easy to win and takes away the challenge from playing. Ideally, the game should be played by two or more human players against each other.

The game could also be better balanced. It feels like some units are stronger than the other ones and items don't have big impact in general. Unfortunately balancing takes a lot of time spent on repetitive playing with small changes.

When it comes to game design, I think I did fairly good job in making each unit different. However, there is only 8 unit classes which is not nearly enough for this genre. Because of that, rerolling becomes almost useless since you have a really big chance of finding the units you want.

Bibliography

[1] Julia Naomi Rosenfield Boeira. *Lean Game Development: Apply Lean Frameworks to the Process of Game Development.* Apress, 2017. ISBN: 978-1-4842-3216-3.

[2] Jesse Schell. *The Art of Game Design: A Book of Lenses.* CRC Press, 2015. ISBN: 978-1-4665-9867-6.

[3] Emily Morrow. *I Want It Now: An Exploration of Competitive Gaming and Instant Gratification* Ritual Motion, 2021, URL: `https://ritualmotion.com/articles/i-want-it-now-an-exploration-of-competitive-gaming-and-instant-gratification/` (accessed: 14. 5. 2022).

[4] Nevada Dru. *JRPG's and Delayed Gratification* Bits and Pieces, 2020, URL: `https://bitsandpieces.games/2020/07/03/jrpgs-delayed-gratification/` (accessed: 14. 5. 2022).

[5] Ben Stegner. *What Are Quick Time Events in Gaming?* MakeUseOf, 2021, URL: `https://www.makeuseof.com/what-are-quick-time-events-in-gaming/` (accessed: 14. 5. 2022).

[6] Craig Robinson. *WHAT IS LEAGUE OF LEGENDS?* Hot Spawn, 2020, URL: `https://www.hotspawn.com/league-of-legends/guides/what-is-league-of-legends` (accessed: 13. 5. 2022).

[7] Jinhang Jiang. *LOL Match Prediction Using Early Laning Phase Data | Machine Learning* Towards Data Science, 2020, URL: `https://towardsdatascience.com/lol-match-prediction-using-early-laning-phase-data-machine-learning-4c13c12852fa` (accessed: 13. 5. 2022).

[8] *Kill to Death Ratio* League of Legends Wiki, URL: `https://leagueoflegends.fandom.com/wiki/Kill_to_Death_Ratio` (accessed: 13. 5. 2022).

[9] *Vision Score* League of Legends Wiki, URL: `https://leagueoflegends.fandom.com/wiki/Vision_score` (accessed: 13. 5. 2022).

[10] Josh Tyler. *League of Legends Guide: 10 Tips to Improve Your Warding* Fansided, 2020, URL: `https://blogoflegends.com/2020/04/24/league-legends-guide-10-tips-warding/` (accessed: 13. 5. 2022).

[11] *Crowd Control* League of Legends Wiki, URL: https://leagueoflegends.fandom.com/wiki/Crowd_control (accessed: 13. 5. 2022).

[12] Christian Vejvad. *What is crowd control score in League of Legends?* Win, 2021, URL: https://win.gg/news/what-is-crowd-control-score-in-league-of-legends-question-mark/ (accessed: 13. 5. 2022).

[13] Richard Heimer. *LOL META: WHAT IT ACTUALLY MEANS* Unranked Smurfs, 2017, URL: https://www.unrankedsmurfs.com/blog/lol-meta-explained (accessed: 13. 5. 2022).

[14] *League of Legends Statistics Terminology and Abbreviations* Factor.gg, URL: https://www.factor.gg/glossary (accessed: 13. 5. 2022).

[15] Michael Kelly. *What is Jungle Proximity in League of Legends?* Dot Esports, 2021, URL: https://dotesports.com/league-of-legends/news/what-is-jungle-proximity-in-league-of-legends (accessed: 13. 5. 2022).

[16] Pav. *Level systems and character growth in RPG games* Pav Creations, 2020, URL: https://pavcreations.com/level-systems-and-character-growth-in-rpg-games/#what-are-levels (accessed: 10. 5. 2022).

[17] Davide Aversa. *GameDesign Math: RPG Level-based Progression* DavideAversa, 2018, URL: https://www.davideaversa.it/blog/gamedesign-math-rpg-level-based-progression/ (accessed: 10. 5. 2022).

[18] *XP* Witcher Wiki, URL: https://witcher.fandom.com/wiki/XP (accessed: 10. 5. 2022).

[19] Nathan Grayson. *A Guide To Auto Chess, 2019's Most Popular New Game Genre.* Kotaku, 2019, URL: https://kotaku.com/a-guide-to-auto-chess-2019-s-most-popular-new-game-gen-1835820155 (accessed: 20.1. 2022).

[20] Brittany Vincent. *Understanding what auto battler games are.* Gaming Street, 2019, URL: https://gamingstreet.com/auto-battler-games-explained/ (accessed: 14.1. 2022).

[21] Matt Cox. *Spawn Point: What on earth is an auto battler?* Rock Paper Shotgun, 2019, URL: https://www.rockpapershotgun.com/what-is-an-auto-battler (accessed: 20.1. 2022).

[22] Ian Boudreau. *This new Dota 2 custom mode is way more popular than Artifact.* PCGamesN, 2019, URL: https://www.pcgamesn.com/dota-2/dota-auto-chess (accessed: 12.1. 2022).

[23] Ryan Gilliam. *Riot Games is making its own League of Legends Auto Chess game.* Polygon, 2019, URL: https://www.polygon.com/2019/6/10/18659021/teamfight-tactics-auto-chess-league-of-legends-riot-games-mode (accessed: 12.1. 2022).

[24] Ryan Gilliam. *Auto Chess creators bringing stand-alone game to PC later this year.* Polygon, 2019, URL: https://www.polygon.com/e3/2019/6/10/18660080/auto-chess-pc-epic-game-store-pc-gaming-show-e3-2019 (accessed: 12.1. 2022).

[25] Wesley Yin-Poole. *Valve releases standalone version of Auto Chess called Dota Underlords.* Eurogamer, 2019, URL: https://www.eurogamer.net/articles/2019-06-14-valve-releases-standalone-version-of-auto-chess-called-dota-underlords (accessed: 14.1. 2022).

[26] Imogen Mellor. *Hearthstone Battlegrounds release date: when to expect the new Hearthstone mode.* PCGamesN, 2019, URL: https://www.pcgamesn.com/hearthstone/battlegrounds-release-date (accessed: 14.1. 2022).

[27] Fraser Brown. *What happened to autobattlers?* PCGamer, 2022, URL: https://www.pcgamer.com/what-happened-to-autobattlers/ (accessed: 5.2. 2022).

[28] Christopher Johansson. *The Popularity of Mobile Gaming* Devdiscourse, 2022, URL: https://www.devdiscourse.com/article/technology/1894806-the-popularity-of-mobile-gaming (accessed: 8.2. 2022).

[29] George Weir. *The Rise Of Auto-Battlers.* The Oxford Student, 2021, URL: https://www.oxfordstudent.com/2021/10/04/the-rise-of-auto-battlers/ (accessed: 20.1. 2022).

[30] *Gold (Teamfight Tactics).* League of Legends Wiki, URL: https://leagueoflegends.fandom.com/wiki/Gold_(Teamfight_Tactics) (accessed: 22.1. 2022).

[31] *Gold.* Dota Underlords Wiki, URL: https://dotaunderlords.fandom.com/wiki/Gold (accessed: 22.1. 2022).

[32] *Gold.* Auto Chess Wiki, URL: https://dotaautochess.fandom.com/wiki/Gold (accessed: 22.1. 2022).

[33] Mehmet Emre Aslan. *How to Comeback From a Bad Start in TFT.* Senpai.gg, 2020, URL: https://senpai.gg/blog/how-to-comeback-tft/ (accessed: 22.1. 2022).

[34] Ed Thorn. *Dota Auto Chess: How to level up and get more XP.* Meta Bomb, 2019, URL: https://www.metabomb.net/dota2/gameplay-guides/dota-auto-chess-how-to-level-up-and-get-more-xp-3 (accessed: 30.1. 2022).

[35] *Player Damage Formula.* LoLChess.gg, URL: https://lolchess.gg/guide/damage (accessed: 30.1. 2022).

[36] *Damage.* Dota Underlords Wiki, URL: https://dotaunderlords.fandom.com/wiki/Damage (accessed: 30.1. 2022).

[37] Ricardo Caetano. *Teamfight Tactics: Breaking down Riot's newest game.* ESPN, 2019, URL: https://www.espn.com/esports/story/_/id/27078221/teamfight-tactics-breaking-riot-newest-game (accessed: 30.1. 2022).

[38] Ed Thorn. *Dota Auto Chess: Skills and abilities list.* Meta Bomb, 2019, URL: https://www.metabomb.net/dota2/gameplay-guides/dota-auto-chess-skills-and-abilities-list-3 (accessed: 2.2. 2022).

[39] *Mana.* Dota Underlords Wiki, URL: https://dotaunderlords.fandom.com/wiki/Mana (accessed: 2.2. 2022).

[40] *Species.* Auto Chess Wiki, URL: https://dotaautochess.fandom.com/wiki/Species (accessed: 30.1. 2022).

[41] Danny Foster. *The definitive Teamfight Tactics item tier list.* Dot Esports, 2021, URL: https://dotesports.com/tft/news/teamfight-tactics-item-tier-list (accessed: 2.2. 2022).

[42] Aaron Alford. *What does MMR mean in gaming?* Dot Esports, 2021, URL: https://dotesports.com/general/news/what-does-mmr-mean-in-gaming (accessed: 2.2. 2022).

[43] Rishov Mukherjee. *What is MMR in League of Legends and why is it a hidden mechanic?* Sportskeeda, 2021, URL: https://www.sportskeeda.com/esports/what-mmr-league-legends-hidden-mechanic (accessed: 2.2. 2022).

[44] Jerome Heath. *Teamfight Tactics ranked, explained.* Dot Esports, 2021, URL: https://dotesports.com/tft/news/how-does-tft-ranking-system-work (accessed: 14.1. 2022).

[45] Zack Palm. *The ranking system in Dota Underlords explained.* Gamepur, 2020, URL: https://www.gamepur.com/guides/dota-underlords-ranking-system (accessed: 2.2. 2022).

[46] MrNiceGuy. *Dota Underlords Ranks & How to Rank-Up.* Dotahaven, 2019, URL: https://www.dotahaven.com/en/guide/dota-underlords-ranks-and-how-to-rank-up/ (accessed: 2.2. 2022).

[47] *Lords of White Spire.* URL: https://underlords.com/leaderboard/standard (accessed: 2.2. 2022).

[48] *Developer Insights: Hearthstone Battlegrounds Rating System Update.* Blizzard Entertainment, 2020, URL: https://playhearthstone.com/en-us/news/23523064 (accessed: 2.2. 2022).

[49] Vicenzo Milella. *DOTA AUTO CHESS: RANK SYSTEM AND DISTRIBUTION - APRIL 2019.* Esports Tales, 2019, URL: https://www.esportstales.com/dota-2/auto-chess-rank-system-and-distribution (accessed: 2.2. 2022).

[50] Amine Issa. *How to Manage your Teamfight Tactics Economy (Three Fundamental Strategies)*. Mobalytics, 2021, URL: https://mobalytics.gg/blog/how-to-manage-your-economy-in-teamfight-tactics-three-strategies/ (accessed: 5.2. 2022).

[51] Kebu Interactive, URL: https://assetstore.unity.com/packages/templates/packs/auto-battles-engine-160472?fbclid=IwAR1dYhOOZRL5iI0z5oju9KE8vI6paiFL6PdeRotpGJKJ1Non_PUKVfGFqRc (accessed: 14.1. 2022).

Appendix A

Contents of electronic appendix

- Builds.zip - contains the build of the project
- Media.zip - contains screenshots from the game
- README.txt - contains link to Google Drive and GitLab, where the Unity project is stored
- latex.zip - contains the thesis in Latex
- project.001, project.002, project.003 - Contains the Unity project. To open it, download 7zip, select these three files, right click them and select "extract here". They will merge into a single file.

Appendix B

User manual

B.1 Launch

To launch the game, open the Builds folder and double click chess.exe.

B.2 Gameplay

The purpose of the game is to purchase pawns, place them on the board and let them fight the enemy pawns. When one of the armies wins, damage is dealt to the loser. The game lasts until either enemy or player lose all their health.

To play, purchase pawns from the shop, then place them on the board and press the start round button. Pawns fight automatically, but their performance will differ according to their position, items and strength.

You can combine units by placing three pawns from the same class with the same number of stars onto the bench. That means three one-star pawns create a two-star pawn and three two-star pawns create a three-star pawn. Three-star pawns cannot be combined anymore.

While dragging a pawn, you can sell it by placing it onto a trash can icon that pops up on the left side of the screen whenever a pawn is picked up. When the icon changes color to red, just release the pawn. When selling a combined pawn, you won't get back 100% of its price, but you still get some gold for selling it.

You gain one item every 5 rounds. Place it on a pawn by dragging the icon from item panel onto a pawn. Each pawn can have only one item. You can remove item from a pawn by either selling the pawn or combining it.

You gain 3 gold at the beginning of each round plus interest. Interest is calculated as floor(current gold/10) and the maximum gain from interest is 5 gold. Also, you gain 1 gold after winning a round.

Each pawn has a health bar and mana bar. They deal auto attacks until their mana bar is full, then they cast their special ability. When the health bar drops to 0, the pawn is removed from the round (but they are respawned for the next round, players do not lose their pawns permanently).

There are three types of damage – physical, magic and true. Physical

damage is mitigated by armor and magic by resistance. True damage ignores both of these statistics.

Each unit class has 1 – 3 traits. These traits are visible in the shop. They activate when a unique pawn from that class is placed on the board. That means that e. g. placing two Kings on the board activates only one Human trait. If there are enough active traits, synergy gets activated. Synergies have 2 – 3 different levels. First level is activated by 2 active traits, second by 4 and third by 6.

B.3 Game components

Figure B.1: The game in an idle state.

Description of components in figure B.1:

1) shop panel

1.1) level button – gives 4 XP for 5 gold, shows current XP/XP needed for a level up and current level

1.2) reroll button – generates 5 new options in the shop for 2 gold

1.3) shop widget – shows offered unit, its price, traits and rarity (rarity is indicated by color of the name – white means common, green uncommon and blue rare); by clicking the widget, offered unit disappears from the shop and is placed onto the bench

2) chance panel – shows chances of units with different rarities appearing in the shop according to current player level; white is for common champions, green for uncommon and blue for rare

3) bench – all unused units are placed here, the bench has 8 slots

4) ally board – units that participate in the upcoming round are placed here

5) current gold – amount of gold player currently has

6) shop button – shop can be toggled with this button
7) health bars
    7.1) enemy health bar – shows how many health points the enemy has
    7.2) player health bar – shows how many health points the player has
8) start round button – this button starts the round

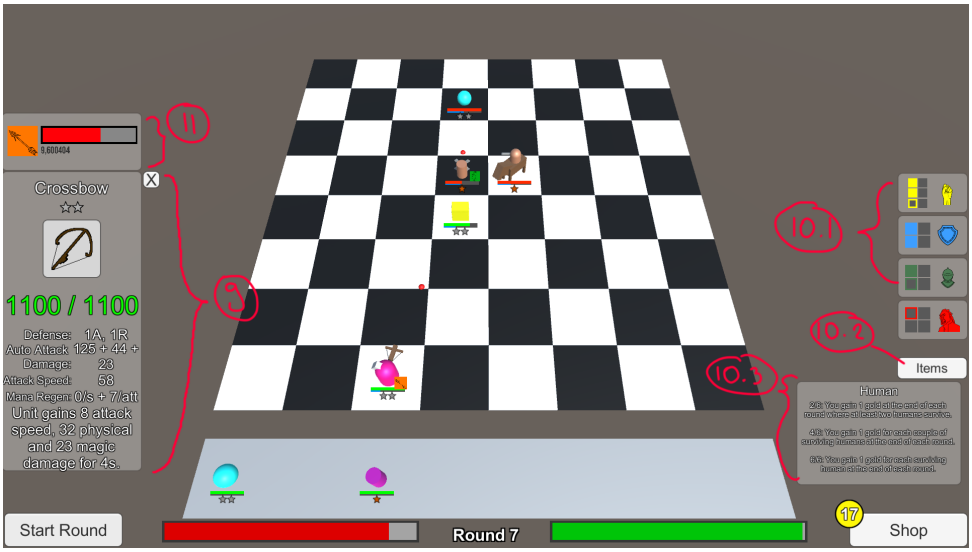

Figure B.2: The game during a fight.

Description of components in figure B.2:
9) unit panel – this panel is opened by clicking on any unit and closed with the X in right top corner; it shows statistics specific for the clicked unit
10) synergies
    10.1) synergy panel – the filled squares represent number of unique active traits (pawns on the board) and the outlined squares number of unique inactive traits (pawns on the bench)
    10.2) toggle button – by clicking this button, you can toggle synergy and item panel
    10.3) tooltip – when hovering mouse over the synergy panel, you can see this panel that provides information about specific synergies
11) item statistics – shows along with unit panel if the unit has an item equipped, provides information about the item usage during the time it was equipped by this specific pawn
Description of components in figure B.3:
12) in-game statistics
    12.1) damage dealt button – switches to damage dealt statistics
    12.2) damage taken button – switches to damage taken statistics
    12.3) damage blocked button – switches to damage blocked statistics
    12.4) health healed button – switches to health healed statistics
    12.5) statistic panel – shows the displayed statistic for every player pawn on the board
13) item panel – stores all unequipped items

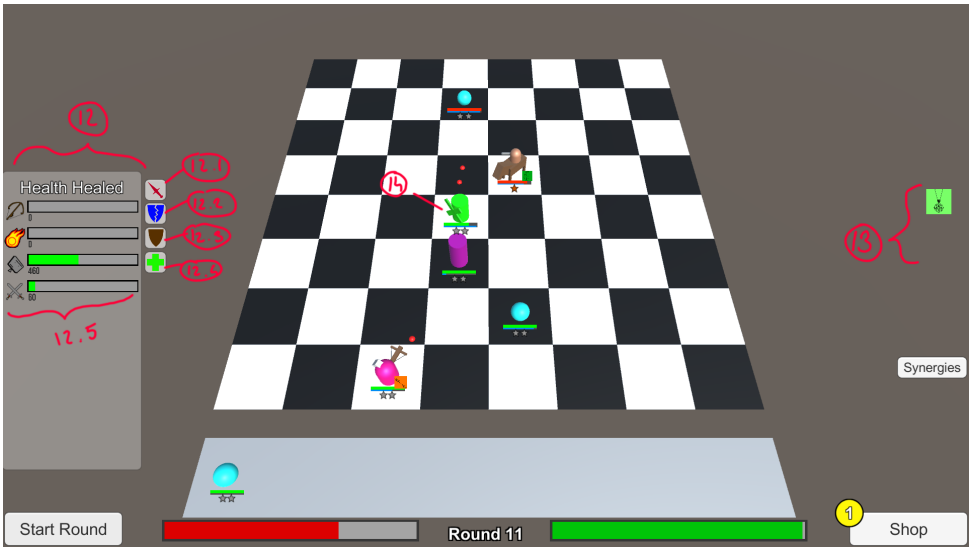

Figure B.3: The game during a fight.

14) colored pawn – when a special attack is used, it is indicated by a change of color

Appendix C

User testing

C.1 Questionnaire

Compulsory questions are labeled with a *.

Introduction
This questionnaire regards evaluating feedback for players in a game, that was created as a bachelor thesis. Before filling in the questionnaire, please spend some time playing mentioned game and exploring its possibilities.

*How old are you?

- < 15
- 15 - 25
- 26 - 35
- 36 - 45
- 46 - 55
- > 56

*What is your experience with video games?

- none
- I played one or two but I don't spend any time on them
- sometimes I play games for fun
- I play games often
- I play games often and also follow events connected to them

*What is your experience with games that belong to autobattle genre (TFT, Autochess, Dota Undergrounds etc.)?

- none
- I briefly tried one of them but it wasn't fun for me
- I started playing one of them recently, I am still learning
- I've been playing one of them for some time
- I've been playing more games from this genre

Comparison with other games
The respondent does not see this section if they answered "none" in the last question from previous section.

*How would you rate the feedback for the player in the project compared to other autobattle games you know?

- feedback in the project was distinctly worse
- feedback in the project was worse
- feedback in the project was comparable to other games
- feedback in the project was better
- feedback in the project was distinctly better
- i don't know
- other (respondent can enter a short answer)

*Which of these components would you like to see implemented in the game you play/used to play? (multiple choice)

- item statistics
- in-game statistics - unit damage, healing etc.
- statistics in the menu - graphs with gold and damage
- match history
- none
- I did not spend enough time on any autobattle games to be able to answer this question
- other (respondent can enter a short answer)

Feedback evaluation

*Which statistic was the most valuable in your opinion?

- item statistics
- in-game statistics - unit damage, healing etc.
- statistics in the menu - graphs with gold and damage
- match history
- none
- other (respondent can enter a short answer)

You can explain your answer here (respondent can enter a long answer)

*Which statistic was the least valuable in your opinion?

- item statistics
- in-game statistics - unit damage, healing etc.
- statistics in the menu - graphs with gold and damage
- match history
- none
- other (respondent can enter a short answer)

You can explain your answer here (respondent can enter a long answer)

*Did the feedback in the form of statistics help you to identify, what you can do better in the next match?

- no, I don't understand the feedback
- no, the feedback doesn't provide enough information
- yes, it helped me to make specific changes during the match
- yes, it helped me to make gradual changes over the course of several matches
- yes, it helped me both to make specific changes during the match and to make gradual changes over the course of several matches
- other (respondent can enter a short answer)

You can explain your answer here (respondent can enter a long answer)

Is there anything you would add or change on the feedback for players in the project? (respondent can enter a long answer)

C.2 Answers

C.2.1 Respondent 1

Úvod

*Kolik je vám let?

- 15 - 25

*Jaké jsou vaše zkušenosti s počítačovými hrami?

- hry hraji často a zajímám se i o dění spojené s nimi

*Jaké jsou vaše zkušenosti se hrami spadajícími do žánru autobattle (TFT, Autochess, Dota Undergrounds a pod.)?

- hraji jednu z nich už delší dobu

Srovnání s ostatními hrami

*Jak se byste zhodnotili zpětnou vazbu poskytovanou hráči v projektu v porovnání s jinými autobattle hrami, které znáte?

- zpětná vazba v projektu byla porovnatelná s jinými hrami

*Který z těchto prvků z projektu byste chtěli, aby byl implementován i ve hře, kterou hrajete/jste hráli?

- statistiky v menu - grafy zlata a poškození

Hodnocení zpětné vazby

*Která ze statistik vám přišla nejužitečnější?

- statistiky ve hře - poškození jednotek, léčení atd.

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Která ze statistik vám přišla nejméně užitečná?

- žádná

Zde můžete rozvést svou předchozí odpověď

- Statistika nuda je, má však cenné údaje...

*Pomohla vám zpětná vazba v podobě statistik k identifikování toho, co můžete v příští hře zlepšit?

- ano, pomohla mi ke konkrétním změnám během zápasu i k postupným změnám v rámci několika zápasů

Zde můžete rozvést svou předchozí odpověď

- (blank)

Je něco, co byste na zpětné vazbě pro hráče v projektu změnili či doplnili?

- (blank)

C.2.2 Respondent 2

Úvod

*Kolik je vám let?

- 15 - 25

*Jaké jsou vaše zkušenosti s počítačovými hrami?

- jednu nebo dvě jsem hrál/a ale nevěnuji se jim

*Jaké jsou vaše zkušenosti se hrami spadajícími do žánru autobattle (TFT, Autochess, Dota Undergrounds a pod.)?

- žádné

Srovnání s ostatními hrami
(section skipped)

Hodnocení zpětné vazby

*Která ze statistik vám přišla nejužitečnější?

- statistiky ve hře - poškození jednotek, léčení atd.

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Která ze statistik vám přišla nejméně užitečná?

- statistiky v menu - grafy zlata a poškození

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Pomohla vám zpětná vazba v podobě statistik k identifikování toho, co můžete v příští hře zlepšit?

- ano, pomohla mi ke konkrétním změnám během zápasu i k postupným změnám v rámci několika zápasů

Zde můžete rozvést svou předchozí odpověď

- (blank)

Je něco, co byste na zpětné vazbě pro hráče v projektu změnili či doplnili?

- (blank)

C.2.3 Respondent 3

Úvod

*Kolik je vám let?

- 15 - 25

*Jaké jsou vaše zkušenosti s počítačovými hrami?

- hry hraji často a zajímám se i o dění spojené s nimi

*Jaké jsou vaše zkušenosti se hrami spadajícími do žánru autobattle (TFT, Autochess, Dota Undergrounds a pod.)?

- hraji jednu z nich už delší dobu

Srovnání s ostatními hrami

*Jak se byste zhodnotili zpětnou vazbu poskytovanou hráči v projektu v porovnání s jinými autobattle hrami, které znáte?

- zpětná vazba v projektu byla porovnatelná s jinými hrami

*Který z těchto prvků z projektu byste chtěli, aby byl implementován i ve hře, kterou hrajete/jste hráli?

- statistiky ve hře - poškození jednotek, léčení atd.
- statistiky v menu - grafy zlata a poškození

Hodnocení zpětné vazby

*Která ze statistik vám přišla nejužitečnější?

- statistiky ve hře - poškození jednotek, léčení atd.

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Která ze statistik vám přišla nejméně užitečná?

- žádná

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Pomohla vám zpětná vazba v podobě statistik k identifikování toho, co můžete v příští hře zlepšit?

- ano, pomohla mi ke konkrétním změnám během zápasu i k postupným změnám v rámci několika zápasů

Zde můžete rozvést svou předchozí odpověď

- (blank)

Je něco, co byste na zpětné vazbě pro hráče v projektu změnili či doplnili?

- (blank)

C.2.4 Respondent 4

Úvod

*Kolik je vám let?

- 15 - 25

*Jaké jsou vaše zkušenosti s počítačovými hrami?

- hry občas hraji pro zábavu

*Jaké jsou vaše zkušenosti se hrami spadajícími do žánru autobattle (TFT, Autochess, Dota Undergrounds a pod.)?

- žádné

Srovnání s ostatními hrami
(section skipped)

Hodnocení zpětné vazby

*Která ze statistik vám přišla nejužitečnější?

- Jiné: tam byly nějaké statistiky?

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Která ze statistik vám přišla nejméně užitečná?

- žádná

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Pomohla vám zpětná vazba v podobě statistik k identifikování toho, co můžete v příští hře zlepšit?

- Jiné: Rozhodně

Zde můžete rozvést svou předchozí odpověď

- (blank)

Je něco, co byste na zpětné vazbě pro hráče v projektu změnili či doplnili?

- (blank)

C.2.5 Respondent 5

Úvod

*Kolik je vám let?

- 46 - 55

*Jaké jsou vaše zkušenosti s počítačovými hrami?

- jednu nebo dvě jsem hrál/a ale nevěnuji se jim

*Jaké jsou vaše zkušenosti se hrami spadajícími do žánru autobattle (TFT, Autochess, Dota Undergrounds a pod.)?

- žádné

Srovnání s ostatními hrami
(section skipped)

Hodnocení zpětné vazby

*Která ze statistik vám přišla nejužitečnější?

- statistiky ve hře - poškození jednotek, léčení atd.

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Která ze statistik vám přišla nejméně užitečná?

- historie zápasů

Zde můžete rozvést svou předchozí odpověď

- koho to zajímá

*Pomohla vám zpětná vazba v podobě statistik k identifikování toho, co můžete v příští hře zlepšit?

- ano, pomohla mi ke konkrétním změnám během zápasu

Zde můžete rozvést svou předchozí odpověď

- (blank)

Je něco, co byste na zpětné vazbě pro hráče v projektu změnili či doplnili?

- (blank)

C.2.6 Respondent 6

Úvod

*Kolik je vám let?

- 15 - 25

*Jaké jsou vaše zkušenosti s počítačovými hrami?

- hry hraji často a zajímám se i o dění spojené s nimi

*Jaké jsou vaše zkušenosti se hrami spadajícími do žánru autobattle (TFT, Autochess, Dota Undergrounds a pod.)?

- hraji jednu z nich už delší dobu

Srovnání s ostatními hrami

*Jak se byste zhodnotili zpětnou vazbu poskytovanou hráči v projektu v porovnání s jinými autobattle hrami, které znáte?

- zpětná vazba v projektu byla hůře zpracovaná

*Který z těchto prvků z projektu byste chtěli, aby byl implementován i ve hře, kterou hrajete/jste hráli?

- historie zápasů

Hodnocení zpětné vazby

*Která ze statistik vám přišla nejužitečnější?

- statistiky ve hře - poškození jednotek, léčení atd.

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Která ze statistik vám přišla nejméně užitečná?

- Jiné: byly tam v pravo nahore pod obchodem nejaky ctverecky s proceny, ktery jsem dlouho nepochopil co znamenaj vubec.

Zde můžete rozvést svou předchozí odpověď

- (blank)

*Pomohla vám zpětná vazba v podobě statistik k identifikování toho, co můžete v příští hře zlepšit?

- ano, pomohla mi ke konkrétním změnám během zápasu

Zde můžete rozvést svou předchozí odpověď

- (blank)

Je něco, co byste na zpětné vazbě pro hráče v projektu změnili či doplnili?

- Kdyz mam koupenou jednotku, nenasel jsem v jejim popisu uz co je za classu (human nebo orc), to by se asi hodilo.