

# Analysis on the Optimal Moves Prediction for Hearthstone

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## ABSTRACT

Even though there are many different game modes in Hearthstone, the main idea is still to combat between players. In classic mode, each player will have its own preconstructed decks and choose one of them after the banning phase. In addition, Battleground is another game mode that contains 8 players, each player will choose a hero to play with. In the game, each round it's a 1v1 combat between 2 players. So in general, Hearthstone is a digital card game in which 2 players compete with each other. Such tournaments measure players' skills and are exciting for viewers, but can take place in a variety of match formats which fans claim drastically affect the competitiveness and viewer engagement. In battleground mode, even though each hero has its own abilities, there should be an optimal way to play each round in order to maximize the player's winning rate. The purpose of this paper is to build a program that can automatically help player make the most optimal move. The idea of this comes from HsReplay, the author uses its database. Even though the whole program is still developing and improving, it contains some basic functions for some specific heroes. This paper provides some references for software development to help players make the optimal moves under certain fixed conditions so that they can win the game eventually.

**Keywords:** hearthstone, card game, deck tracking, game theory, games

## 1. INTRODUCTION

Throughout time, there are a lot of card games: Hearthstone, Dungeons & Dragons, Yu-Gi-Oh! Duel Links or even poker games, all of them have a large number of players. According to Playercounter and Ghost Network Protocol technology: "our team spent a week monitoring the activity at different times of the day and came to the conclusion that between 150,00 and 280,000 people play Hearthstone concurrently in July 2021", this large amount of players indicate how popular card games are these days, they are easy to learn, fun to play and normally it is free.

However, the database of a card game can be large. Even though there are only 52 cards in poker, there are varieties of games that can cause different rules of how we use those cards which can imply many different variations. In Hearthstone, there are more than 4.568 playable cards in classic mode and in battleground mode, there are 140 cards along with 67 unique heroes that players can choose from [1]. For some heroes, their abilities are easy to utilize. For example, hero Millificent Manastorm's ability is that all Mechs type creatures will

gain +1/+1, so when my program runs it will tell this player to buy mainly Mechs instead of another type of creatures. Another example will be Chenvaala, after he plays 3 Elements, the cost of Bob's tavern will be reduced by 3. Thus, the program will ask him to buy all elements before Tavern reaches level 6 which is the maximum level. However, not all heroes are as simple as Chenvaala and Millificent Manastorm. One of my favorite heroes is The Lich King, he can give a friendly minion Reborn effect, which the author needs to calculate each creature The Lich King controls and find out which creature has the greatest potential values so that by giving him Reborn, my total gain is maximized.

A little bit of game theory is used in this project, where other player's moves can be predicted. For example, if my this-round opponent is Millificent Manastorm, then the author shall expect most of opponent's creatures to be Mechs, and one of the main features of Mechs is Divine Shield which can block damage once. Thus the author shall tell the player to purchase Unstable Ghoul [2] in order to break all Divine Shields.

The purpose of this paper is to optimize gamers' experiences and make them better at this game. If this project can give out the player's best move each round, people can learn how to make the optimal move by using this HsTracker. In this way, in the future when player goes to a tournament, if build-in app is not allowed, he can make the right move.

## 2. BATTLEGROUND MATCH STRUCTURE

All Hearthstone Battlegrounds matches have the exact same structure, see Figure 1 to know the flow of a match. All matches start from the recruit phase, which each player can pick from 4 different heroes if he purchased a battle pass or 2 different heroes if he did not. Each player will receive different options meaning that if Player A has Millificent Manastorm under his choice then Millificent Manastorm will not appear under other players' choices. After the recruit phase, the game will start and it will enter a combat phase where two players fight with each other based on minions' strength and abilities. However, if there are uneven numbers of players, then one of the players will fight with Kel'Thuzad who is a dummy hero. Kel'Thuzad does not have any abilities, also Kel'Thuzad has all the creatures and tavern tiers of a previous defeated player. Normally,

Kel'Thuzad is a lot weaker than all other players since he cannot purchase any creatures and use any abilities, but if a player loses the fight with him, the player will still receive damage based on tavern tiers and creature tiers.

So far, Hearthstone officials have not announced under what circumstances the player will match with Kel'Thuzad, but according to user id 42694825 on NGA [3], there are 4 rules. The first one is only the last three players have the right to fight with Kel' Thuzad, meaning that if there exists 5 players (since only when there are uneven numbers of players, one of them will face Kel'Thuzad), then the 1st player and the second player will not meet Kel' Thuzad. The second rule is for each round Player A has not met with Kel' Thuzad, the chances of him fighting with Kel' Thuzad will increase with a certain number. The third rule is that if Player A keeps winning then the chances of him meeting Kel' Thuzad will decrease with a certain number. And the last rule is, even if you keep losing, it will not increase your chance of fighting Kel' Thuzad next round. These four rules are very useful since fighting with Kel' Thuzad basically means that this player can take a rest this turn without worrying about losing health.

Moreover, player has a free round to look for his key card which will boost his winning rate.

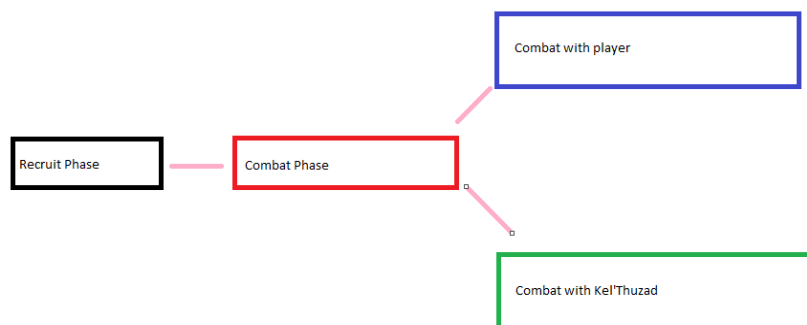


Figure 1 The flow of a Hearthstone Battlegrounds match

## 3. DETAILS OF HSTRACKER

When the player enters the recruiting phase, the player will choose from either two or four heroes, which HsTracker will show tiers of each hero. However, HsTracker does not have a built-in function to store and

analyze each hero's tier, thanks to HsReplay [4], this program can solve that problem for me. Figure 2 shows what it looks like in HsReplay. During the recruit phase, the player can pick the hero with the highest winning rate. Even though the player might not pick the one with the highest winning rate, it can still acknowledge the player which hero is currently most powerful.

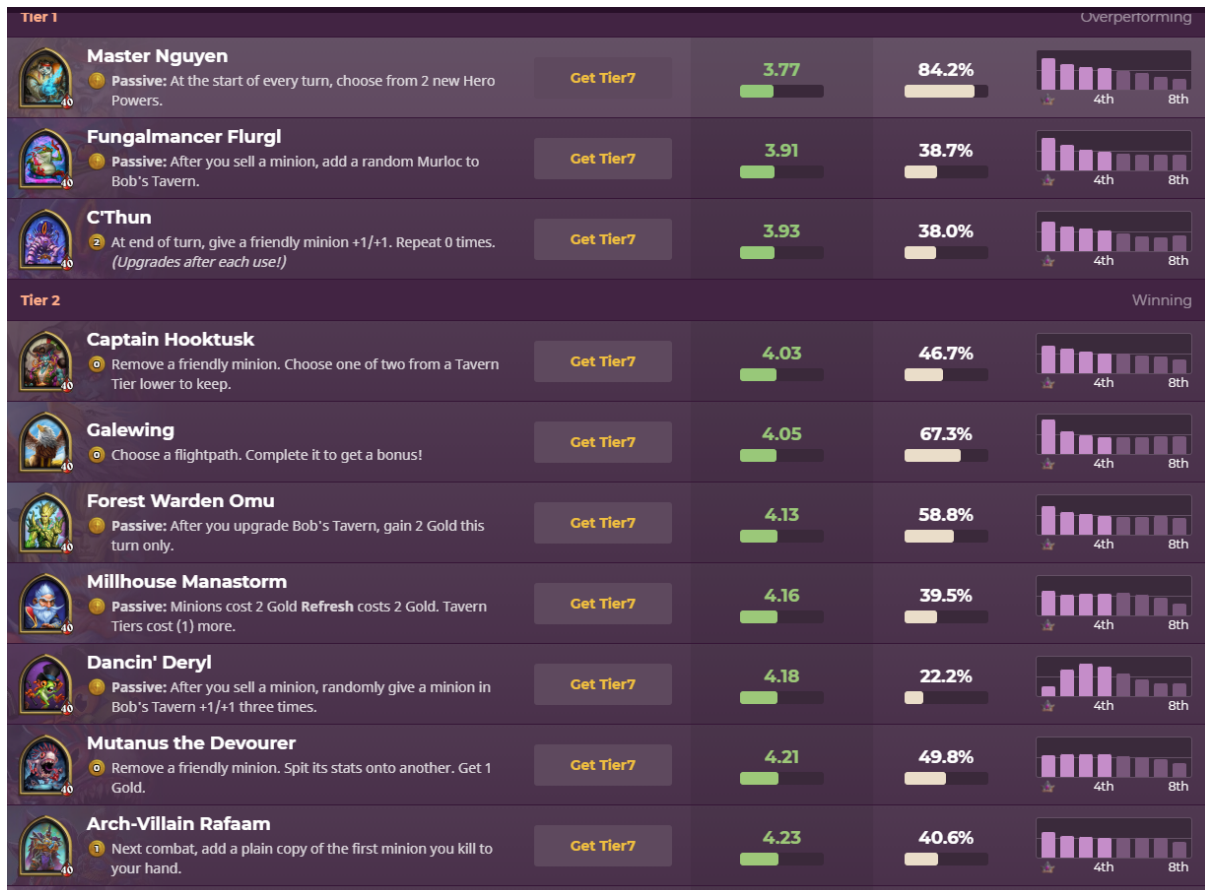


Figure 2. An example of what HsReplay looks like

During matches of Hearthstone Battlegrounds, the system will show us what the majority type of creatures another player has. If there is no majority, then it will show Mixed. This information can be combined with which hero that player is playing to better analyze his board. For example, if Player A is playing Galakrond [5] and the system tells us the player has dragons as his main creature type, then most likely he will have Kalecgos, Arcane Aspect [6], or Razorgore, the Untamed [7] due to Galakrond's ability. This can help us better prepare for the next round of battle by predicting what we will fight against.

Another approach of implementation of game theory in HsTracker is to predict what other players will do after their prediction. Just like we are using HsTracker to predict other players, they can also predict our moves. If the author is playing George the Fallen and there are only two people left, then HsTracker will assume Player B will have an Unstable Ghoul as his first creature to attack. Thus the author knows for sure that it is a 6v7 battle since Unstable Ghoul is not considered as a creature that can cause any threats to me. The counter solution will be having a Selfless Hero [8].

Another feature of HsTracker is it will track how many points the player lost today and shows him which composition helped him receive the most points. This way player can gain a better understanding of which

composition the player plays the best and if he wants to use the same strategy next time, he has some knowledge of how to do it from round 1.

#### 4. FUTURE WORK

HsTracker is a huge project and there is still a lot of things the author need to work on. Due to the limitation of knowledge, the author have not yet learned how to implement HsTracker into Hearthstone or even make it an app. Currently, HsTracker is just a bunch of Java codes in my local computer.

On the one hand, some heroes are especially hard to analyze. Its ability is difficult to decide when to use them. A great example is Zephyrs, the Great [9], ideally, his ability should be cast when there are two same minions in the player's hand but what if there are more important minions? The player might want to save this ability later when he finds the more important one since Zephyrs's ability can only be cast three times. On the other hand, Master Nguyen is another problem for HsTracker. His ability is "At the start of every turn, choose from 2 new Hero Powers", this requires a large number of codes along with a good sense of logic in order to find out which ability is more useful each round. There are a lot of heroes that the author can not put inside of HsTracker because the author has no idea how to code them, the author hopes to improve this in my future work.

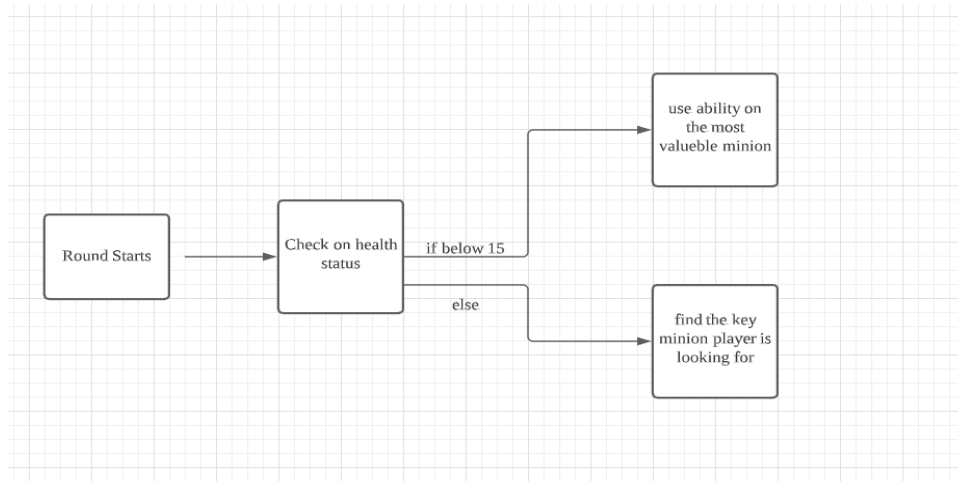


Figure 3. Workflow of the logistic of how program works

At the beginning of each round, HsTracker will check on the player's health first, if it is less than 15 then HsTracker will suggest the player use his ability so that he will be less likely to lose health points in the next fight. Or if the player has more than 15 health points, it is more unlikely this player will be killed during the next fight so he can keep looking for his key minions.

However, this workflow in Figure 3 can cause some other problems that need to be fixed, for example, how should HsTracker determine which minion is the most valuable one, this cannot be done simply by looking at one's tiers or strength, some minion has lower strength and health points but has more potential values. In addition, even though the player might have more than 15 health points, it could be better to use his ability this round. These are some problems that HsTracker will need to focus on in the future.

### 5. HOW DOES PART OF THE PROGRAM WORK?

First part of the program contains a scanner object that will scan through a file containing all card information.

```

File file = new File("D:\\summerresearchproject");
Scanner scanFile = new Scanner(file);
while(scan.hasNextLine()) {
    String line = scan.nextLine();
    String[] split = line.split(",");
    ArrayList<Card> cardObject = new ArrayList<Card>();
    for (int i = 1; i < split.length; i++) {
        Card newcard = new Card(split[0],split[1],Integer.parseInt(split[2]),Integer.parseInt(split[3]),Integer.parseInt(split[4]));
        cardObject.add(newcard);
    }
}
  
```

```

}
}
  
```

The file, in this case, will have all card information stored in the following format: Name of the card, type of the card, the tier of the card, the strength of the card, and the health of the card. An example will be: Tarecgosa,Dragon,3,4,4

Next, we will have a switch statement that will contain all heroes, in the example below I used Patchwerk and George the Fallen as my example. If the player picked Patchwerk then it will enter a method called Patchwerk:

```

public static void PatchwerkCase()
{
    playerHP = 50;
    if (playerHP <= 20)
    {
        safeModeSwitch = false;
    }
    if (playerHP <= 10)
    {
        normalModeSwitch = false;
    }
}
  
```

In this program, there are three modes: the normal mode, the safe mode, and the danger mode. If a player has HP higher than 20 then all three modes will be activated (meaning all three switches will be set to true), else if HP is between 10 and 20 then the safe mode will be banned and when a player has HP below 10 then danger mode will be activated. For safe mode, the program will encourage players to buy MurlocTidehunter, Alleycat or Sellemental, because those three minions need 3 manas to buy but they have the value of 2. Or if

there is none appeared on the board, we encourage players to refresh.

However, in danger mode, this paper will detect if there is a minion on board that could combine with our own minions so that we would have a triple. If we do then we will encourage the player to do a triple or else refresh.

```
if (levelUp) {
    buy(theMissingOne);
}
else {
    refresh();
}
```

In the other case where the player picked George The Fallen, then it will be a little more complicated case. The best deck comp that fits with George is Murloc so we will encourage players to buy as many Murloc as possible. Also, Brann Bronzebeard is a key card for the Murloc deck so if the player is currently under level 4 and he has a triple on board, then we encourage the player to freeze the board and do level up his tiers. Until he is at tier 4 so that when he receives a triple reward he might be able to get a Brann Bronzebeard which is at tier 5. Or if he is currently at tier 4 then he should receive that triple reward.

```
if (playerTier < 4 && levelUp)
{
    LevelUp();
    freeze();//freeze and do level up
}
else if (playerTier == 4 && levelUp)
{
    tripleRewards(currentCard);
}
```

## 6. BEYOND HEARTHSTONE

HsTracker has more potential than just a plugin for Hearthstone. Dominic Calkosz and James McCann [10] explained in their paper that their program - HearthNash can be used in other games that have the same structure as Hearthstone such as Magic: The Gathering or even multiplayer online battle arenas (MOBAs). They think all of these games contain deck-building and pre-gameplay draft phase, "it would also allow for mathematical and objective comparisons between these two games which have not been possible before. Even games outside of the card game genre could utilize the same structure for determining optimal strategies, including fantasy sports drafting." as they stated in their essay. The author thinks that the same logic can be implemented for HsTracker since all card games or even some other strategy games

such as Slay the Spire also need players to make decisions each round. For example, in Slay the Spire, a player will fight with an opponent with health points from 8-999 and each round the player will have at least five cards in his hand that can either do damage or gain blocks which will counter the opponent's damage. In this case, each round player needs to choose wisely whether he wants to attack the opponent or simply dodge the damage. Even though the format of the two games is different, the logic can be the same.

## 7. CONCLUSION

There are a large number of card games in the world and Hearthstone is one of the most famous ones, it also has a large number of fans. One of the most important things fans care about is how to get better at this game and improve their own skills, even though there are programs like HsReplay or HearthNash, none of them can give players a clear guide on how to play a specific hero each round. This is the main purpose why the author wanted to develop HsTracker, to help the player realize where they did wrong and help them improve their skills, in another word, optimal each move. Even though HsTracker works fine on some of the heroes, it still has limitations. One of them is HsTracker currently can not be implemented due to lack of knowledge. The other main difficulty is when a player picks an advanced hero, HsTracker does not work on that hero. What's more, HsTracker has a great potential of working on other games or fields. Even though HsTracker is designed for Hearthstone, its function and idea do not limit to this specific game. The author believes that any type of game that has a decision-making phase can implement HsTracker to optimal each move made by the player.

## ACKNOWLEDGMENT

Many thanks to HsReplay, it gives the author the idea of making HsTracker. Also thank you for providing me this large database of heroes and minions.

Thanks to Dominic Calkosz and James McCann from Carnegie Mellon University for giving me some great thoughts on this essay and also some supports on how to solve some specific problems.

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