

# League of Legends: Item Recommendation

ECE 225A | by Young Li, Simon Fong

## Context

"League of Legends is a 2009 multiplayer online battle arena video game. League of Legends is often cited as the world's largest e-sport, with an international competitive scene. The 2019 World Championship had over 100 million unique viewers, peaking at a concurrent viewership of 44 million, with a minimum prize pool of US\$2.5 million." For comparison, the Super Bowl currently averages about 100 million viewers. The game is "a team-based strategy game where two teams of five powerful champions face off to destroy the other's base."



Figure 1. A Game of League of Legends from one player's perspective.

Each player controls a unique champion which has a set of different attacks and stats such as strength and defense. They are more specific, but in essence, some stats help you kill, and some stats help you from being killed. While there are usually 5 players on each team, each player of each team has a role that determines where on the map they will play. The roles are as follows: top, middle, jungle, bottom, and support.



Figure 2. The map where players battle.

Roles		
Name	Location	Description
Top	Top	Plays in the top lane.
Middle	Middle	Plays in the middle lane.
Jungle	Jungle	Plays in the no lane, but stay in the jungle.
Bottom	Bottom	Plays in the bottom lane doing most of the damage.
Support	Bottom	Plays in the bottom lane and assists the bottom lane player.

Since each player on each team plays a specific role, they often usually just have to match up against their counterpart on the other team in the lane that they chose. Blue top fights Red top, Blue middle fights Red middle. This means how well they do in the game can mostly be

attributed to how they approach the matchup against their opponent. Approaches can vary drastically depending on a player's playstyle, teammates, and etc, but one major aspect that is important is what items a player chooses to buy. An item in the game is something a player can buy for their champion using in-game currency, gold, that they earn during the game. This item can enhance a player's offensive and/or defensive capabilities.

## Quick Stats

Champions	148+
Items	175+

## Questions

1. Given my current champion and my opponent's champion, which items should I buy which maximizes my chance of winning?

## Data

### Kaggle

For the majority of our tasks, we will be using a League of Legends match dataset from Kaggle. It contains data about 100K matches in the Korean region for the highest-ranked players in challenger, grandmaster, and master in the 2020 season. These represent the best 0.06% of players in the Korean region which is known as the most competitive region in the world.

### League of Legends API

While we can gain a lot of insights from the aggregated data from Kaggle, it does not give us the full picture of the match. So to have a better understanding we will use the League of Legends API to gather more information such as: translating champion ids to champion names and pictures, translating item ids to item names and pictures, and retrieving the full match information to understand what exact game events happened when.

# Techniques

## General Preprocessing

For general preprocessing, we needed this absolutely since we are dealing with 100K matches each containing information about 10 different players on hundreds of different stats each. The best way we did this was to create a much smaller dataset of only 1000 matches which we saved to disk and reloaded accordingly. This made testing small changes very fast and made sure we didn't waste too much time just waiting. When everything worked on the small sample, we slowly scaled up and fixed issues accordingly.

Additionally, since there hundreds of different features in each match, we carefully selected a handful we thought were meaningful based on our experience playing the game and focused on those since it would have been intractable to attempt to understand every little statistic.

## Understanding

While the data was useful for calculating probabilities, it is almost meaningless and useless if we do not know what champion id 1 and item id 3000 refer to in the actual game. So to allow the average player to use our results, we used the League of Legends API to translate ids to meaningful names that we are familiar with. Additionally, most of the time, players do not actually know the names of each champion and/or item, so we integrated the API to also fetch the item/champion image when we are displaying our results, so it is much more digestible.

## Items to Maximize Winning Probability

For this, we will use a very simple technique. We find all the matches that contain our current champion and the target opponent champion. Then, for each item that our current champion bought, we collect all the games that have that item on that champion. Next, we find the probability of winning.

Let  $C$  be our current champion, let  $O$  be the opponent champion where  $C, O \in \{1, \dots, 148\}$ . Let  $I$  be some item that our current champion  $C$  has, where  $I \in \{1, \dots, 175\}$ . We want to find the following. Let  $W$  be the event of a win. Let  $M$  be the number of games that have  $C, O$ , and  $I$ . Let  $M_{win}$  be the number of games that the champion  $C$  is on the winning side in those circumstances.

$$P(W|C, O, I) = \frac{M_{win}}{M}$$

Let's call  $P(W|C, O, I)$  for a given item  $I$  the win-rate,  $WR$ , of that item in the match-up of  $C$  against  $O$ . For example, if our current champion  $C$  is Shen, the opponent champion,  $O$  is

Teemo, and the item  $I$  is Adaptive Helm. The  $WR_{Shen,Teemo,AdaptiveHelm} = 67\%$ . Below we have a full table detailing the best and worst items, ranked by win rate, to buy as playing as Shen against an enemy Teemo.

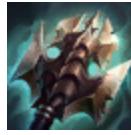
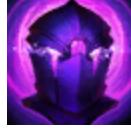
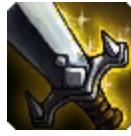
Some things to note while looking at this table. Since there are more than 148 champions in this

game there are  $\binom{148}{2}$  different possible matchups, this amounts to 10,878 different possible matchups. While a dataset of 100K+ matches may seem large, when compared to the matchup space it is rather small. This is why we only found 20 matches in 100K+ matches where we have Shen against Teemo. This small sample means we can't trust the results too much, but as we get more data, we can apply the same methods to reduce variance.

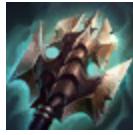
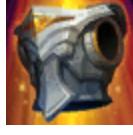
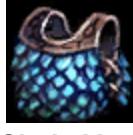
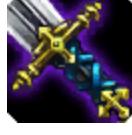
Another aspect about sample size is that since there are 175+ items in the game we have a similar problem to our matchup space in that we have a small sample size. While the B.F. Sword item having a stellar 100% win rate, it means very little when we see that it has only been used once. Therefore, to have better trust in our results, we will only recommend the items which have been used in at least 50% of the time in this matchup.

While we only have the recommended items for a select few matchups, since we created reusable functions, this can easily be run for any matchup and can generate recommendations for the 10K+ different possible matchups.

### Match-Up (44 Matches)

	
<b>Shen</b>	<b>Fiora</b>
<b>Best Against Fiora</b>	<b>Worst Against Fiora</b>
 <b>Ninja Tabi</b> Win Rate: 59% Uses: 37	 <b>Titanic Hydra</b> Win Rate: 50% Uses: 20
 <b>Thornmail</b> Win Rate: 58% Uses: 19	 <b>Farsight Alteration</b> Win Rate: 42% Uses: 12
 <b>Doran's Shield</b> Win Rate: 58% Uses: 24	 <b>Adaptive Helm</b> Win Rate: 33% Uses: 6
<b>Small Sample Size</b>	
 <b>Aegis of the Legion</b> Win Rate: 100% Uses: 1	 <b>Executioner's Calling</b> Win Rate: 0% Uses: 2

### Match-Up (18 Matches)

	
<b>Shen</b>	<b>Singed</b>
<b>Best Against Singed</b>	<b>Worst Against Singed</b>
 <b>Titanic Hydra</b> Win Rate: 89% Uses: 9	 <b>Mercury's Treads</b> Win Rate: 40% Uses: 10
 <b>Ninja Tabi</b> Win Rate: 75% Uses: 4	 <b>Adaptive Helm</b> Win Rate: 33% Uses: 9
 <b>Gargoyle Stoneplate</b> Win Rate: 75% Uses: 4	 <b>Spirit Visage</b> Win Rate: 33% Uses: 3
<b>Small Sample Size</b>	
 <b>Chain Vest</b> Win Rate: 100% Uses: 2	 <b>B. F. Sword</b> Win Rate: 0% Uses: 1

### Match-Up (20 Matches)



**Shen**

**Best Against Teemo**

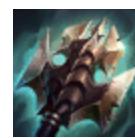


**Teemo**

**Worst Against Teemo**



**Adaptive Helm**  
Win Rate: 67%  
Uses: 12



**Titanic Hydra**  
Win Rate: 38%  
Uses: 13



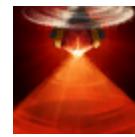
**Sunfire Cape**  
Win Rate: 55%  
Uses: 11



**Doran's Shield**  
Win Rate: 42%  
Uses: 12



**Mercury's Treads**  
Win Rate: 50%  
Uses: 16



**Oracle Lens**  
Win Rate: 43%  
Uses: 14

### Small Sample Size



**B. F. Sword**  
Win Rate: 100%  
Uses: 1



**Negatron Cloak**  
Win Rate: 0%  
Uses: 2

# Insights

1. Given my current champion and my opponent's champion, which items should I buy which maximizes my chance of winning?
  - a. Shen vs Fiora
    - i. I should buy Ninja Tabis, Thornmail, and Doran's Shield to maximize my chances of winning.
  - b. Shen vs Singed
    - i. I should buy Ninja Tabis, Gargoyle Stoneplate, and Titanic Hydra to maximize my chances of winning.
  - c. Shen vs Teemo
    - i. I should buy Adaptive Helm, Sunfire Cape, and Mercury Treads to maximize my chances of winning.
  - d. These are only three matchups, but since I often play Shen and I am usually unsure which items to buy against these enemy champions, this will help me in my future games against these champions.

## Item Value Analysis

Next we were curious about item value and the win rates of teams who build at least one of the items that we are trying to analyze. There are public sources that suggest what are popular builds for specific champions online, however there is no source that analyzes each item individually. In this part of our data analysis, we do a quick analysis on the win rate of items. That is the probability of winning given that at least one person on your team built the item.

Let  $W$  be the event that you win

Let  $I$  be the event that at least one person has the item

Let  $L$  be the event that you lose

We want to know  $P(W|I)$  and  $P(L|I)$ . We can do that by using a simple method of iterating through all of the players and checking their item.

We can do this by iterating through all of the player items in every match and running our statistical analysis.

How many people built this item and lost: 359

How many games were lost when at least one person built this item: 296

How many people built this item and won: 372

How many games were won when at least one person built this item: 320

How many times did this item lose when the other team didn't have it: 177

How many times did this item win when the other team didn't have it: 201

There are a couple of statistics that we care about because it is possible that the other team might want the same item. That is why we have these specific metrics and we can do a calculation by doing  $(\text{wins})/(\text{wins} + \text{loss})$  and  $(\text{loss})/(\text{wins} + \text{loss})$  for win ratios and loss ratios. I have defined a method to do this analysis for a specific item ID, which makes this function easy to use.

Some of the downsides are this might only reveal the value of some items, if we see some very high win rates where the winning team builds it but the losing team doesn't it could be used to suggest that the item has good value and the team that bought the item got good value for the gold they spent. However, this doesn't reveal the true synergy of the item and a specific champion matchup. There are many things in the equation that could dictate whether an item is truly good or synergises well and we would be able to keep track of it. However, for the sake of the assignment and our curiosity, we were interested in the win rate of the items.

## Champion Early vs Late game analysis

The last thing we have explored is early game versus late game champion win ratios. This is actually a very interesting question for league of legends players because it can help with team composition synergies during champion pick/ban phase. Champions that are considered "late game" champions are champions that would scale really well with 5-6 item builds or just have higher stats in the late game. We have created an algorithm to check the win ratios of a specific champion before 20 minutes, between 20 and 30 minutes, between 30 and 40 minutes and beyond 40 minutes. This would be a fun thing to experiment and to see how well champions scale into the late game. So for this specific case I have also created a function that iterates through our data to find exactly this.

```
This champion won: 12 times before 20 minutes.  
This champion won: 20 times in between 20 and 30 minutes.  
This champion won: 7 times in between 30 and 40 minutes.  
This champion won: 2 times after 40 minutes.  
This champion lost: 15 times before 20 minutes.  
This champion lost: 18 times in between 20 and 30 minutes.  
This champion lost: 5 times in between 30 and 40 minutes.  
This champion lost: 2 times after 40 minutes.
```

With this, we can use a similar formula described above to find the win rates at specific time frames. This is  $(\text{wins})/(\text{wins} + \text{loss})$  and  $(\text{loss})/(\text{wins} + \text{loss})$ . In this specific case, we only care about the champion and game duration. It could also be nice to see pairs of champions that work well together. This is worth mentioning because, this only compares one single champion with ANY teammate champions. So, this does not take into account specific matchups or anything like that.

## What's Next

One major problem we had faced is a lack of data while this may seem odd given the 100K+ matches which consist of a few gigabytes of data, it makes sense given the champion matchup space and item space. To solve this problem, we could in the future better take advantage of the

League of Legends API to periodically extract the match data from the 50+ million daily players around the world. This would quickly help us fill our data gap.

Furthermore, if we want to make this more accessible to the overall player base, we could convert our analysis into a full web application that the public could use and check data on specific matchups with our recommendations.

## Resources

1. [https://en.wikipedia.org/wiki/League\\_of\\_Legends](https://en.wikipedia.org/wiki/League_of_Legends)
2. [https://en.wikipedia.org/wiki/Super\\_Bowl\\_television\\_ratings](https://en.wikipedia.org/wiki/Super_Bowl_television_ratings)
3. <https://na.leagueoflegends.com/en-us/how-to-play/#:~:text=League%20of%20Legends%20is%20a,battle%20your%20way%20to%20victory.>
4. <https://www.kaggle.com/gyejr95/league-of-legendslol-ranked-games-2020-ver1>
5. <https://developer.riotgames.com/docs/lol>