

Big Data Analysis on CS:GO Game Mechanism based on Spark

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About CS:GO

Counter-Strike:Global Offensive is a first-person shooter game pitting two teams of 5 players against each other. Within a maximum of 30 rounds, the two teams find themselves on either side as a Counter Terrorist or Terrorist. Both sides are tasked with eliminating the opposition or, as the terrorist team, planting the C4 bomb at a bomb site and allowing it to explode. Rounds are played out until either of those two objectives or if the maximum time is reached (in which the counter terrorists then win by default). At the end of the 15th round, the two teams switch sides and continue until one team reaches 16 round wins first.^[1]

More competitive mechanics can be found at Wikipedia. ^[2]

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Dataset Introduction

- Using Dataset of CS:GO Competitive Matchmaking Data from Kaggle: <https://www.kaggle.com/datasets/skihikingkevin/csgo-matchmaking-damage>

The screenshot shows a Kaggle dataset page. At the top, there's a header with user info (KP - UPDATED 4 YEARS AGO), a notebook count (208), a 'New Notebook' button, a download link ('Download (631 MB)'), and a more options menu. Below the header is the title 'CS:GO Competitive Matchmaking Data'. Under the title, it says 'Damage/Grenade entries on over 410k rounds played in competitive Counterstrike'. To the right of the title is a thumbnail image showing a first-person view of a CS:GO map with various in-game elements like a red spawn point and blue stairs. At the bottom of the page, there are links for 'Data', 'Code (21)', 'Discussion (6)', and 'Metadata', followed by an 'About Dataset' section and a 'Usability' rating of 7.94.

Fig. 1-2: Kaggle Dataset

Dataset Contents

ESEA Datasets:

- *meta_demos*: meta data of rounds
- *dmg_demos*: damaging events
- *kill_demos*: killing events
- *grenades_demos*: grenade using events

Common rounds Datasets:

- *mm_master*: damaging events
- *mm_grenades*: grenades using events

General Data:

- *map_data*: map bound positions

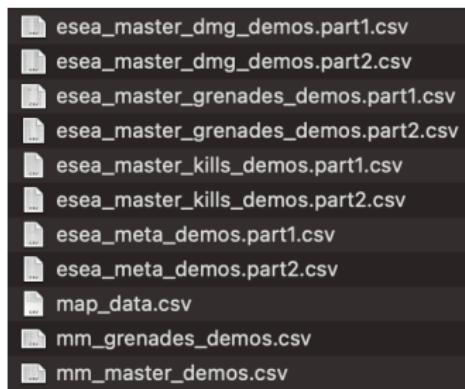


Fig. 1-3: csv files in dataset

Dataset Contents

Mainly show the tables in ESEA Datasets, there are 377,629 rounds, 10,538,182 damage records, 2,742,646 killing records and 5,246,458 grenades using records in total.

A	B	C	D	E	F	G	H	I	J	K	L	M	
1	Re	round	state	round_start	round_end	winner	item	winner_idle	joined_race	(L1,L2,L3)	W		
2	resea.match.13770987.item			44.307182	165.0551	merits	Headshots	Territorial	Pistol_Round	4300	4255		
3	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405		
4	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405		
5	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405		
6	resea.match.13770987.item			4	341.0064	454.4259	merits	Headshots	Teritorial	NORMAL	24800	25480	
7	resea.match.13770987.item			4	341.0064	454.4259	merits	Headshots	Teritorial	NORMAL	24800	25480	
8	resea.match.13770987.item			6	454.2180	604.5590	merits	Headshots	Teritorial	NORMAL	24800	25480	
9	resea.match.13770987.item			7	604.5590	604.5590	merits	Headshots	Teritorial	NORMAL	24800	25480	
10	resea.match.13770987.item			10	735.8691	844.8671	merits	Headshots	Counter_Territorial	FORCE_BUY	32150	18500	
11	resea.match.13770987.item			10	735.8691	844.8671	merits	Headshots	Counter_Territorial	FORCE_BUY	32150	18500	
12	resea.match.13770987.item			12	2033.002	1089.536	Arena	Style	Counter_Territorial	NORMAL	20350	22080	
13	resea.match.13770987.item			12	2033.002	1089.536	Arena	Style	Counter_Territorial	NORMAL	20350	22080	
14	resea.match.13770987.item			13	2088.9081	1371.8686	Arena	Style	Counter_Territorial	NORMAL	21130	19800	
15	resea.match.13770987.item			14	2113.9480	1211.1960	Arena	Style	Counter_Territorial	TERMINAL	21130	19800	
16	resea.match.13770987.item			15	2113.9480	1211.1960	Arena	Style	Counter_Territorial	TERMINAL	21130	19800	
17	resea.match.13770987.item			17	2209.0320	1299.0553	Arena	Style	Counter_Territorial	NORMAL	22000	21450	
18	resea.match.13770987.item			18	2209.0320	1299.0553	Arena	Style	Counter_Territorial	NORMAL	22000	21450	
19	resea.match.13770987.item			19	2552.1482	1586.2237	merits	Headshots	Counter_Territorial	ECO	21150	1500	
20	resea.match.13770987.item			19	2552.1482	1586.2237	merits	Headshots	Counter_Territorial	ECO	21150	1500	
20	resea.match.13770987.item			20	2610.1509	1789.0767	merits	Headshots	Counter_Territorial	ECO	21400	4400	

(a) Contents of meta table

A	B	C	D	E	F	G	H	I	J	K	L	M
1	Re	round	state	round_start	round_end	winner	item	winner_idle	joined_race	(L1,L2,L3)	W	
2	resea.match.13770981.item			3.3528	80.1455	Arena	Style	merits	Headshots	Territorial	YES	
3	resea.match.13770981.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
4	resea.match.13770981.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
5	resea.match.13770981.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
6	resea.match.13770981.item			17	40.7644	173.1865	Arena	Style	Counter_Territorial	YES		
7	resea.match.13770981.item			17	40.7644	173.1865	Arena	Style	Counter_Territorial	YES		
8	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
9	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
10	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
11	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
12	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
13	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
14	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
15	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
16	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
17	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
18	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
19	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		
20	resea.match.13770981.item			17	171.9460	1229.0320	Arena	Style	Counter_Territorial	TERMINAL		

(c) Contents of kill table

A	B	C	D	E	F	G	H	I	J	K	L	M
1	Re	round	state	round_start	round_end	winner	item	winner_idle	joined_race	(L1,L2,L3)	W	
2	resea.match.13770987.item			341.0064	454.4259	merits	Headshots	Teritorial	Pistol_Round	4300	4255	
3	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
4	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
5	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
6	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
7	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
8	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
9	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
10	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
11	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
12	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
13	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
14	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
15	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
16	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
17	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
18	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
19	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	
20	resea.match.13770987.item			2020	355.9581	213.3090	Headshots	Teritorial	ECO	3035	18405	

(d) Contents of gre table

Hierarchical Structure

The fields in ESEA match dataset table are shown as Fig. 1-5, each row stands for the same field among four dataset tables.

Use file+round can find same entries among the dataset, the Hierarchical Structure are shown as Fig. 1-6.

meta	master_dmg	master_kill	master_grenade
file	file	file	file
round	round	round	round
click	click	click	click
start_seconds	seconds	seconds(round)	seconds
end_seconds	att_team	att_team	att_team
winner_team	vic_team	vic_team	vic_team
winner_side	att_side	att_side	att_side
round_type	vic_side	vic_side	vic_side
ct_eq_val	hp_dmg	hp_dmg	hp_dmg
t_eq_val	arm_dmg	arm_dmg	arm_dmg
is_bomb_planted	is_bomb_planted	is_bomb_planted	is_bomb_planted
bomb_site	bomb_site	bomb_site	bomb_site
hitbox	hitbox	hitbox	hitbox
wp	wp	wp	wp
wp_type	wp_type	wp_type	wp_type
att_id	att_id	att_id	att_id
att_rank_0	att_rank_0	att_rank_0	att_rank_0
vic_id	vic_id	vic_id	vic_id
vic_rank_0	vic_rank_0	vic_rank_0	vic_rank_0
att_pos_x	att_pos_x	att_pos_x	att_pos_x
att_pos_y	att_pos_y	att_pos_y	att_pos_y
map	vic_pos_x	vic_pos_x	vic_pos_x
vic_pos_x	vic_pos_y	vic_pos_y	vic_pos_y
vic_pos_y	nade	nade	nade
	nade_land_x	nade_land_x	nade_land_x
	nade_land_y	nade_land_y	nade_land_y
ct_alive			
1_alive			

Fig. 1-5: Fields in ESEA Dataset Tables

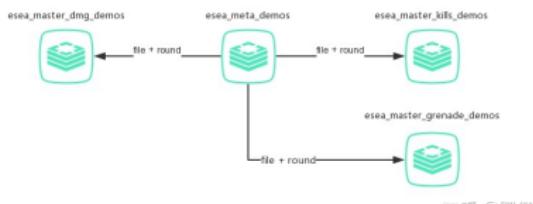


Fig. 1-6: Dataset Hierarchical Structure[3]

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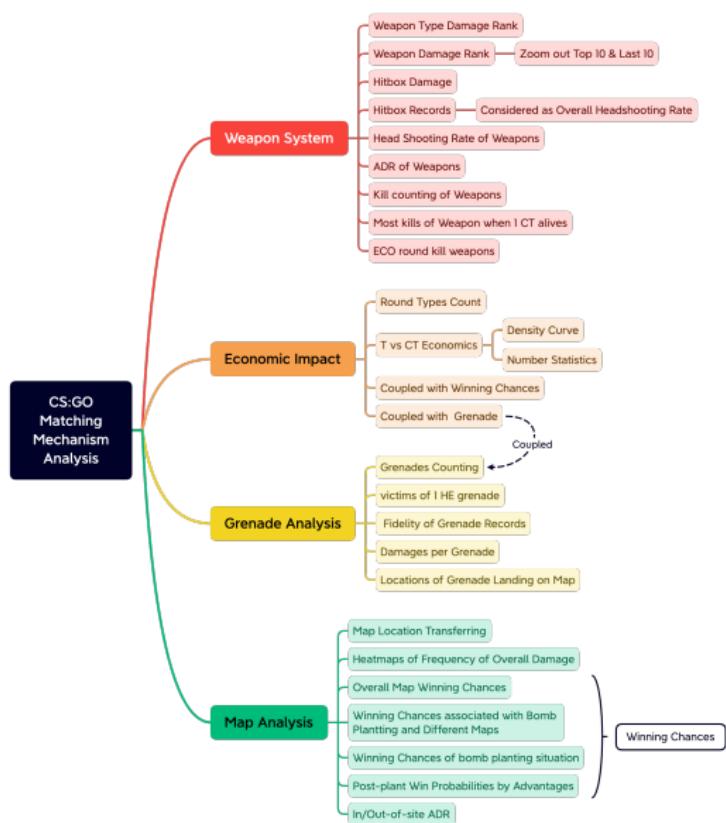
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All analysis goals are shown as Fig. 2-7, there are 4 parts, **25 research goals** in total. To expand, we mainly study the following four parts of game matching mechanism and gamer behaviors.

Weapon System

From ranking weapon characteristics to find out popularities.

- **Weapon Type Damage Rank**
- **Weapon Damage Rank**
- **Kill counting of Weapons**

Analyze shooting area, head shooting rate and power of weapons.

- **Hitbox Damage**
- **Hitbox Records**
- **Head Shooting Rate of Weapons**
- **Power of Weapons**

Then analyze the player behavior preferences.

- **Most kills of Weapon when 1 CT alive**
- **ECO round kill weapons**

Economics Impact

Count the rounds in different types.

- **Round Types Count**

Analyze the economics by comparing the total equipment value.

- **Density Curve**
- **Number Statistics**

And we also want to analyze the connection among the economics, winning chances and grenade buying situation, in order to see if they are relative.

- **Coupled with Winning Chances**
- **Coupled with Grenade Using**

Grenade Analysis

CS:GO is a hard core game basically depending on the level of aiming and positioning, but grenades are essential part of managing the game play. We wonder does grenades still matter a lot in matching game plays, and if *High-Explosive* grenades have any effect in the game.

We mainly have these two targets in this section:

- **Grenades Counting**
- **victims of 1 HE grenade**

And the grenades landing locations pointed on maps. Which is similar to the heat map analysis.

- **Grenade Locations**

Map Analysis

Analyze *winning rate* in different maps, and the association with bomb planting situation.

- **Overall Map Winning Chances**
- **Winning Chances associated with Bomb**
- **Planting site counts in different Maps**
- **Winning Chances of bomb planting situation**

Analyze the winning chance when have advantage after the bomb planted, and analyze the effect of different defending positions.

- **Post-plant Win Probabilities by Advantages**
- **In/Out-of-site ADR**

Draw a heat map of the most attack points of both sides.

- **Heatmaps of Frequency of Overall Damage**

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Experiment Platform

Use the distributed cluster of the Tianjin University laboratory as experiment platform.

Environment versions:

- 3 nodes CentOS 8 Linux 4.18.0-383.el8.x86_64
- Hadoop: 2.7.5
- JAVA: 1.8.0_161
- Spark: 2.2.1, Scala: 2.11.8
- Python: 3.7.3
- Jupyter: 4.4.0

```
(base) [root@39d62 ~]# neofetch
...
PLTJ.
<><><>
KKSSV! 4MKK L3 K00L. "VSSKK
KKV" 000KKK L3 K000AL .VKK
V! "VMKKK L3 K00KV" ! V
,4MA, "VMK L3 KKV" ,4M0,
. K00KKA, "V L3 V" .K000K .
,4D K00K00KA, " L3 " .K00K00KK FA,
>QD ++++++***** +*****+***** GFD>
'VD K0KKKKKKK' , L3 ..'KKKKKKKK FV
* VKKKKK' , .. L3 K, .KKKKKK ' VV'
,4MK L3 KKA, ., KV'
A, .,4MKK L3 K00KA, ., 4
KKA, .K00K L3 K000K" ,4KK
KKSSA, VKKK L3 K00V ,4SSKK
<><><>
'PNOR'
...
root@39d62
OS: CentOS Linux 8 x86_64
Host: OptiPlex 7088-China HDD Protection
Kernel: 4.18.0-383.el8.x86_64
Uptime: 1 day, 23 hours, 5 mins
Packages: 380 (rpm)
Shell: bash 4.4.19
Terminal: /dev/pts/1
CPU: Intel i7-10700 (16) @ 4.800GHz
GPU: NVIDIA GeForce GTX 1650
GPU: Intel CometLake-S GT2 [UHD Graphics 630]
Memory: 938MiB / 31665MiB
```

Fig. 3-8: System Information

Programming Architecture

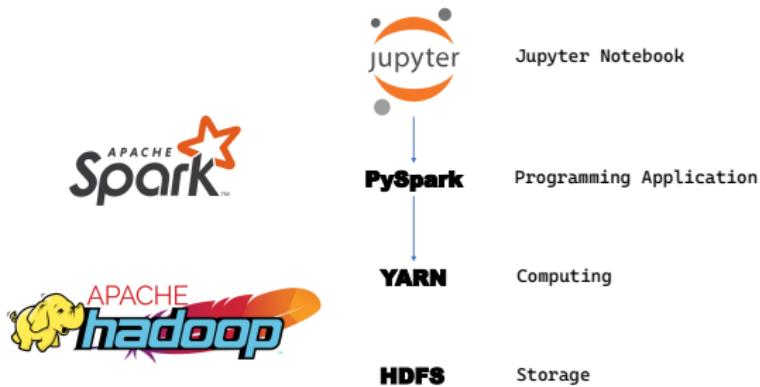


Fig. 3-9: Analysis Architecture

We run the PySpark application on one of the nodes by client mode.

Hadoop has high availability and has distributed file storing and resource managing frameworks, and it has a grand ecosystem supporting many kinds of computing applications and APIs, such as Apache Spark, which supports Python programming.

- We use Spark running on YARN, and use Hadoop [4] HDFS for distributed file system to store input files and output results.
- Using PySpark APIs to program in Python on Jupyter Notebook.
- All dataset files are uploaded to the HDFS on cluster servers. And the map pictures are copied from HDFS to local on the node for map plotting analysis.
- Jupyter Notebooks are stored in the local node, which could be accessed from webpage on port 9595.

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Analyzing Flow

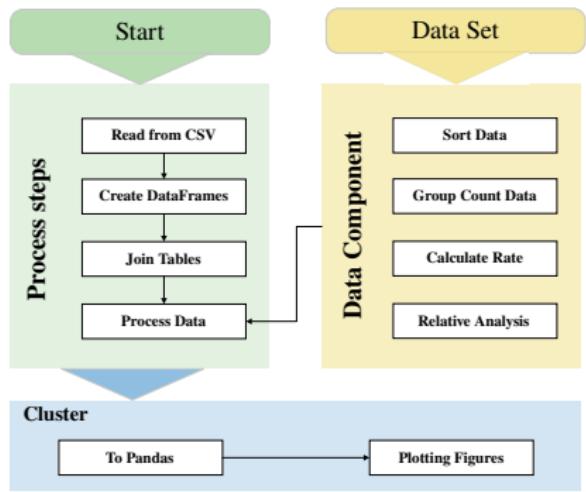


Fig. 3-10: Analyzing Flow

Use the `sqlContext` environment of Spark Session, import data from HDFS, and create RDDs; create DataFrames, and link different tables.

Analyzing by grouping statistics, sorting, and calculating on the DataFrame; and send results to Pandas.

Data visualization: Use tools like `plt` and `seaborn` to draw charts,1 and two-dimensional density distribution graphs.

Here is a example of data process of counting bomb platting site of every rounds in the `mm_master_demos` table.

Convert Pandas output to \LaTeX format, shown as Table 3-1.

```
1 #统计炸弹安放点
2 site_count_pd=mm_rgl_df.filter
3     ("bomb_site!='"').select([
4         'file', 'map', 'round', 'bomb_site']).dropDuplicates()
5     () . \
6         groupby(['map', 'bomb_site'])
7         .count().toPandas()
8 #送入Pandas, 转置, 显示:
9 site_count_pd.set_index(['map',
10     , 'bomb_site']).unstack()
```

Table 3-1: Example table of the bomb site counting to Pandas

bomb_site map	count	
	A	B
de_cache	1819	1375
de_cobble	346	434
de_dust2	2123	1537
de_inferno	1065	938
de_mirage	2544	1955
de_overpass	428	557
de_train	257	204

Here is the same example visualization: output figure shown as Fig. 3-11.

```
1 fig = plt.figure(figsize=(6, 8))
2 colors1=sns.color_palette("hls",2)
3 sns.barplot(y='count',x='map',
4               hue='bomb_site',data=
5               site_count_pd,palette=
6               colors1)
7 plt.suptitle('Victims per HE',
8              fontsize=16, fontweight='bold')
9
```

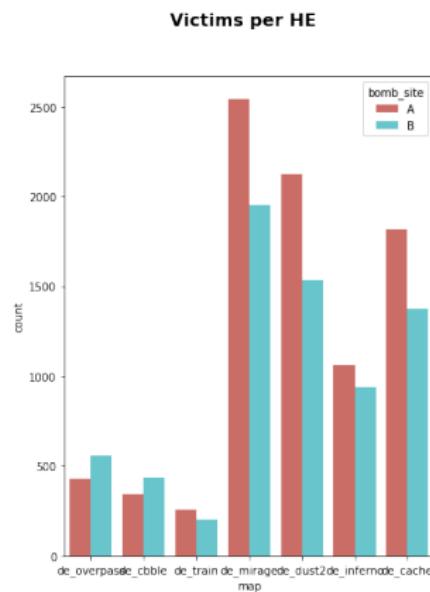


Fig. 3-11: Example Picture

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Read from files

Import the 6 csv tables required for the analysis into RDD, then fill in the fields according to the RDD, create a DataFrame, and finally form 6 DataFrames: `meta_df`, `dmg_df`, `kill_df`, `gre_df`, `mm_df` and the map bound data `map_bounds`.

- ① Import csv files, cut *headers* then create and union RDDs.
- ② Fill the fields and create DataFrame from RDDs.

Here we can print the Schemas to see the fields of these DataFrames(Fig. 3-12).

```
root
|-- ct_eq_val: long (nullable = true)
|-- end_seconds: string (nullable = true)
|-- file: string (nullable = true)
|-- map: string (nullable = true)
|-- round: long (nullable = true)
|-- round_type: string (nullable = true)
|-- start_seconds: string (nullable = true)
|-- t_eq_val: long (nullable = true)
|-- winner_side: string (nullable = true)
|-- winner_team: string (nullable = true)
```

(a) meta Schema

```
root
|-- att_side: string (nullable = true)
|-- att_team: string (nullable = true)
|-- bomb_site: string (nullable = true)
|-- ct_alive: string (nullable = true)
|-- file: string (nullable = true)
|-- is_bomb_planted: string (nullable = true)
|-- round: string (nullable = true)
|-- seconds: string (nullable = true)
|-- t_alive: string (nullable = true)
|-- tick: string (nullable = true)
|-- vic_side: string (nullable = true)
|-- vic_team: string (nullable = true)
|-- wp: string (nullable = true)
|-- wp_type: string (nullable = true)
```

(b) kill Schema

```
root
|-- arm_dmg: string (nullable = true)
|-- att_pos_x: string (nullable = true)
|-- att_pos_y: string (nullable = true)
|-- att_side: string (nullable = true)
|-- att_team: string (nullable = true)
|-- bomb_site: string (nullable = true)
|-- file: string (nullable = true)
|-- hitbox: string (nullable = true)
|-- hp_dmg: string (nullable = true)
|-- is_bomb_planted: string (nullable = true)
|-- round: string (nullable = true)
|-- seconds: string (nullable = true)
|-- tick: string (nullable = true)
|-- vic_pos_x: string (nullable = true)
|-- vic_pos_y: string (nullable = true)
|-- vic_side: string (nullable = true)
|-- vic_team: string (nullable = true)
|-- wp: string (nullable = true)
|-- wp_type: string (nullable = true)
```

(c) dmg Schema

```
root
|-- arm_dmg: string (nullable = true)
|-- att_id: string (nullable = true)
|-- att_pos_x: string (nullable = true)
|-- att_pos_y: string (nullable = true)
|-- att_side: string (nullable = true)
|-- bomb_site: string (nullable = true)
|-- file: string (nullable = true)
|-- hitbox: string (nullable = true)
|-- hp_dmg: string (nullable = true)
|-- is_bomb_planted: string (nullable = true)
|-- nade: string (nullable = true)
|-- nade_land_x: string (nullable = true)
|-- nade_land_y: string (nullable = true)
|-- round: string (nullable = true)
|-- seconds: string (nullable = true)
|-- vic_id: string (nullable = true)
|-- vic_pos_x: string (nullable = true)
|-- vic_pos_y: string (nullable = true)
|-- vic_side: string (nullable = true)
```

(d) grenades Schema

Fig. 3-12: Schemas of the rest of DataFrames

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Explanation

We only show final results and chart figures in this section, mainly divided into the following four parts: **Weapon system**, **Economics impact**, **Grenade analysis** and **Map analysis**.

The entire procession in detail can be found in the report and code.

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Weapon types

There are 8 types of weapon in the CS:GO game, the summarized damages are shown as Table 4-2.

Table 4-2: Damages of Different weapon types

wp_type	tot_dmg	hp_dmg	arm_dmg
Rifle	177745516.0	156448524.0	21296992.0
Pistol	76737824.0	67355345.0	9382479.0
Sniper	39695267.0	38710578.0	984689.0
SMG	27397275.0	23032905.0	4364370.0
Grenade	15249803.0	13021114.0	2228689.0
Heavy	2325035.0	2039414.0	285621.0
Unkown	1854692.0	1295327.0	559365.0
Equipment	583514.0	543252.0	40262.0

Here are occupation of total damage and HP & Armor damages. The most damage to armor is the Rifles, followed by pistols, submachine guns, grenades, sniper rifles, heavy weapons and equipment.

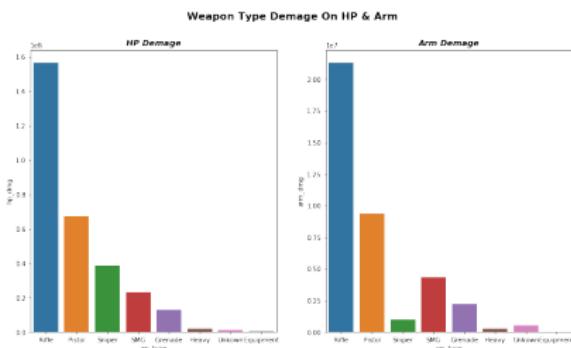
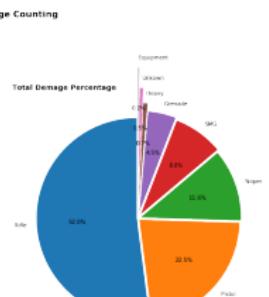
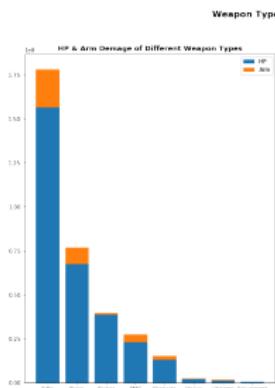


Fig. 4-13: Damage occupations of different weapon types

Fig. 4-14: HP and Armor damages of different weapon types

Weapon Ranking

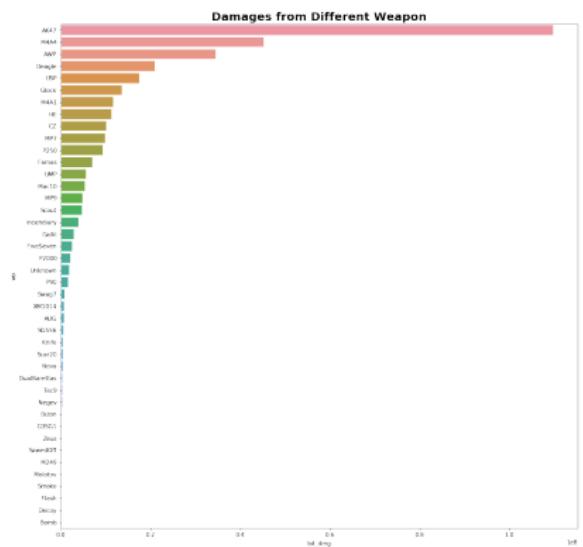


Fig. 4-15: Damages of different weapons

Fig. 4-16: Damage occupation of different weapons

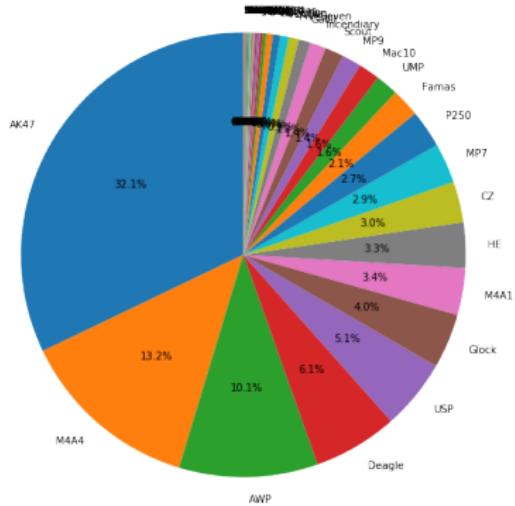


Fig. 4-16: Damage occupation of different weapons

Fig. 4-15 and Fig. 4-16 show the *total damages* 40 weapons in 7 weapon types, *zooming* in

Fig. 4-17.

AK47 takes the highest in Rifles, AWP takes the most in Snipers, Desert Eagle takes the most in pistols, and it leads the rest of guns, including other Rifles and all of SMGs.

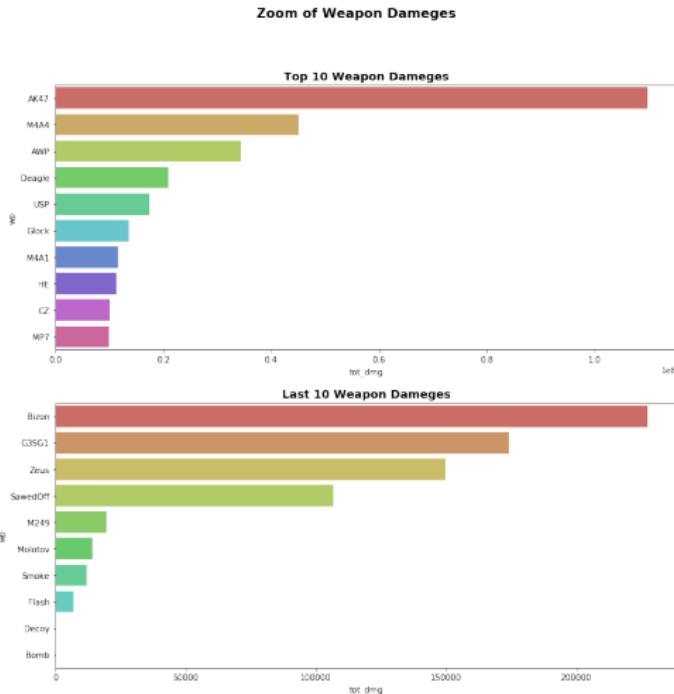


Fig. 4-17: Damage occupation of different weapons

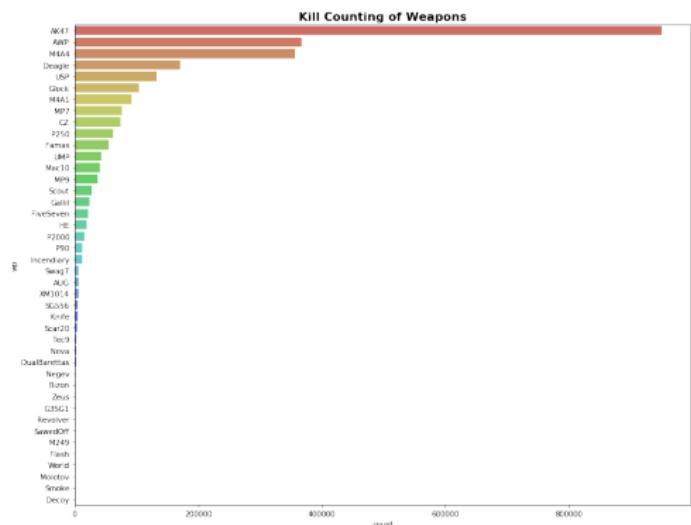


Fig. 4-18: Killing counting of different weapons

We can make a deduction from killing count that players often buy AK-47, M4A4 and AWP in common, and buy Desert Eagle and MP7 in economic weak rounds. And most popular weapon to CT is AK-47 (Fig. 4-19), most popular weapon in ECO rounds is Desert Eagle (Fig. 4-20).

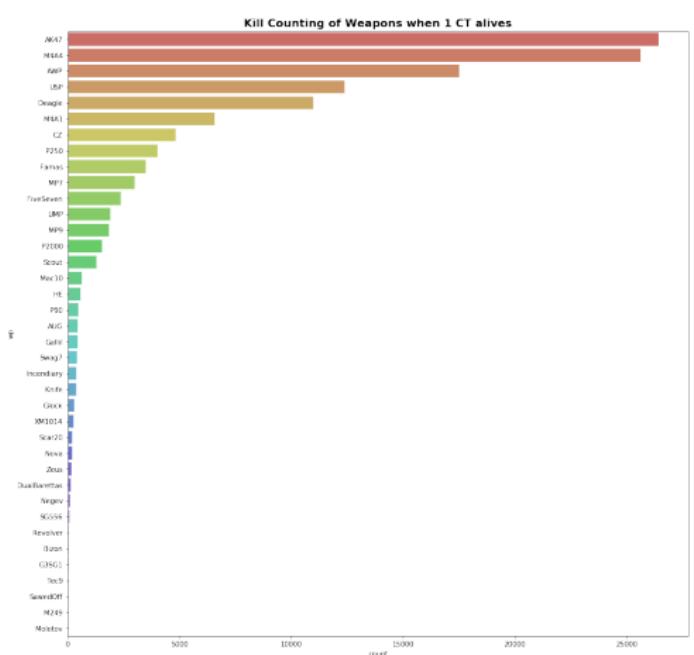


Fig. 4-19: Killing counting of CT when 1 alive

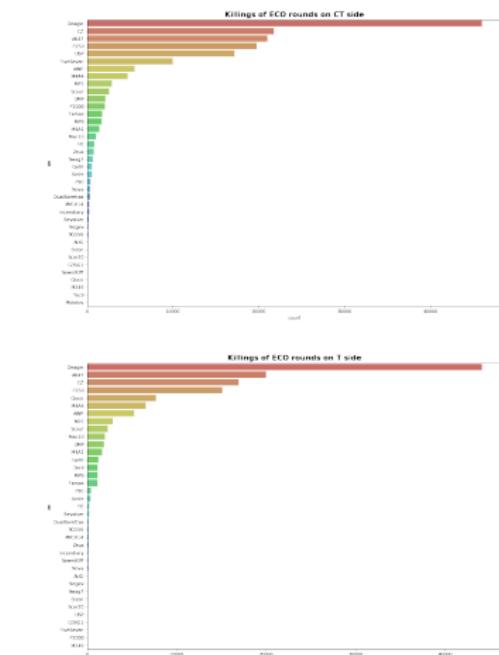


Fig. 4-20: Killing weapons in ECO rounds

Hitbox Prosperities

The stomach has more damage entries than the head, but the total damage amount of the head is higher than that of the stomach.

The overall headshot rate is only 16%. More damage is generated by the Rifles hitting the chest and abdomen.

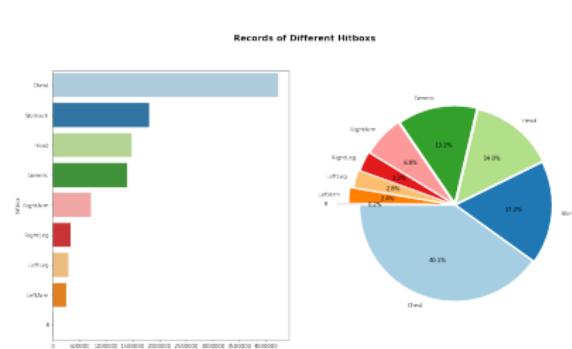
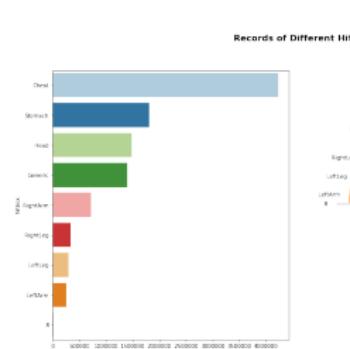
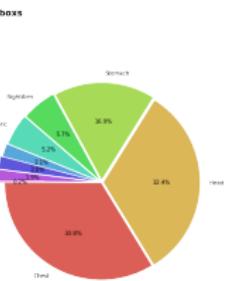
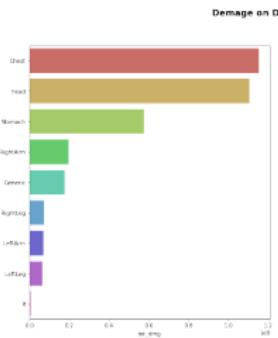


Fig. 4-21: Total damages of different hitbox

Fig. 4-22: Records of different hitbox

Head shooting rate & Power

USP is the highest heat shooting rate weapon; Stun gun, then sniper AWP and Scout and Scar20 takes the most power. Desert Eagle is highest in pistols, and AK-47 in Rifles.

Head Shot Rate of Weapons

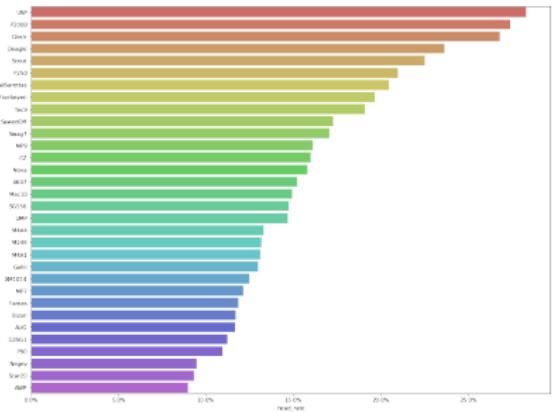


Fig. 4-23: Head Shooting Rate of Weapons

Average Damage per Shot of Weapons

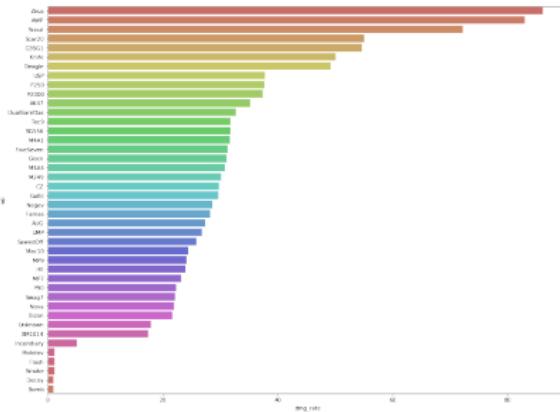


Fig. 4-24: Average Damage per shot of Weapons

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Round Type Counts

Normal rounds take 41.2% of all rounds, and over a quarter rounds are ECO rounds. ECO rounds often appears in the game.

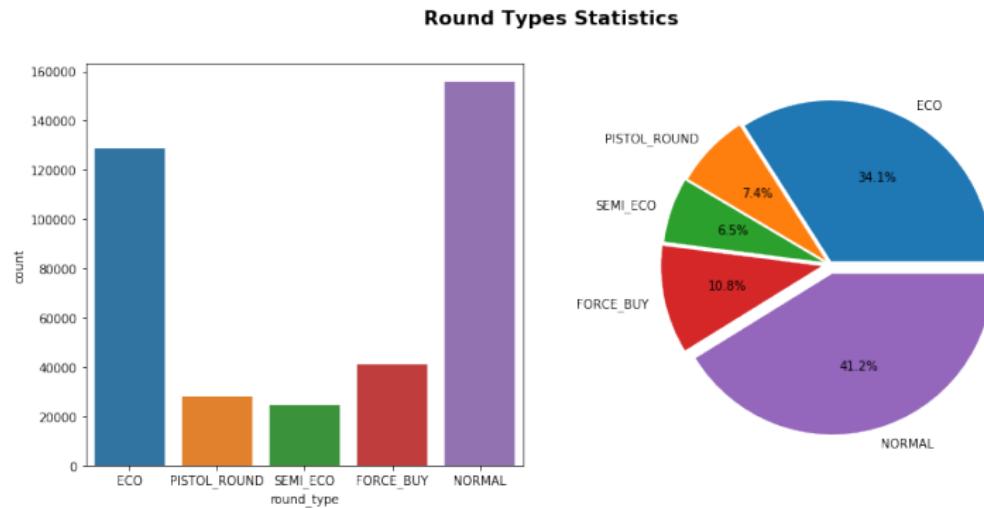


Fig. 4-25: Round Types Counting

Economics Comparison

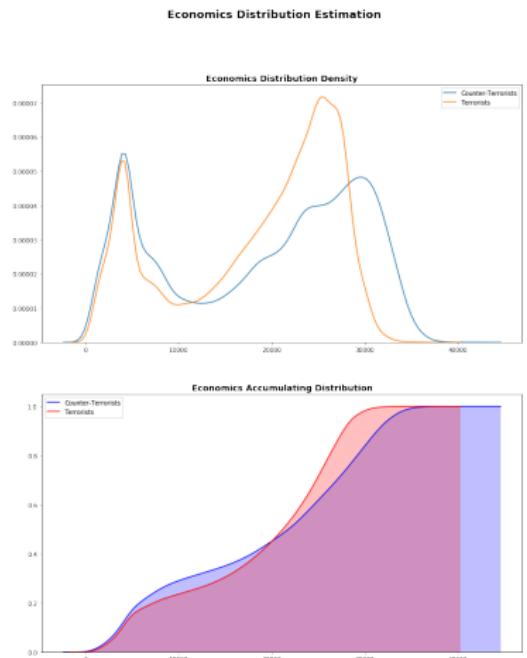


Fig. 4-26: Economic Distribution Curves

Group 13

CS:GO Game Mechanism Analysis

Both T and CT tend to buy *few equipment or a lot*.
The CT economy is slightly higher than the T economy, and CT economy is more volatile.

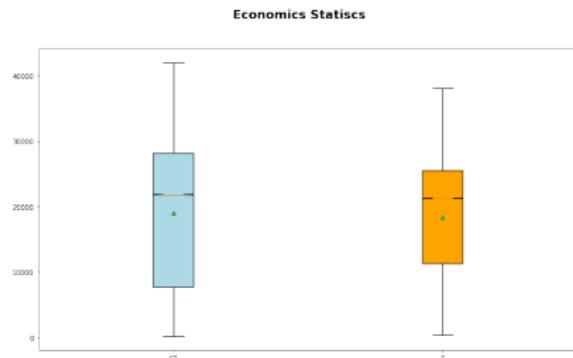


Fig. 4-27: Economic Box Plot

Impacts

The density curve reflects the positive correlation between economy and win rate on T & CT sides. (Fig. 4-28)

More economics lead to more grenade using, and CT need more economics to buy grenades than T does.



Fig. 4-28: Winning Rounds on Economics Difference

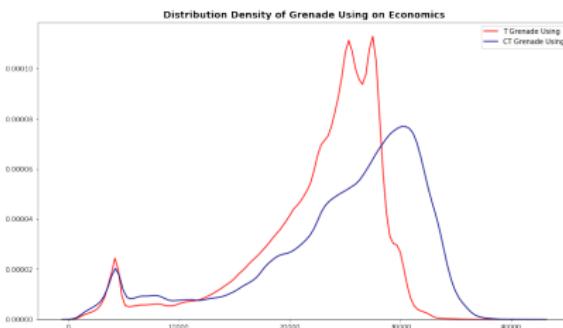


Fig. 4-29: Distributing density of grenade using records on equipment value

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Using Records

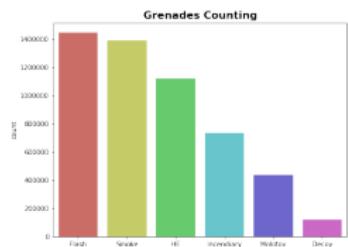


Fig. 4-30: Grenade Using Records Count

Flash are used the most. The CT use incendiary is 30% more frequent than the T use Molotov, but the economy is higher.

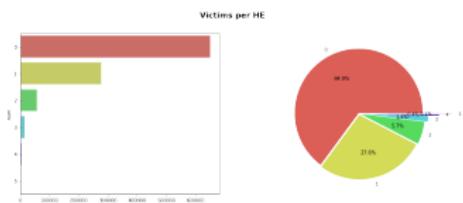


Fig. 4-31: Victims per one HE grenade

This shows that especially in the professional league, the role of HE grenades is more to repel the enemy, or to attack the enemy who is alone.

Damages of grenades

Most High-Explosive grenades cost zero HP damage, and the ARM damages remain below 20.

The Molotov has mostly damages at 1, that because it can cause 1 damage at a time, and max damage is 4, but incendiaries of CT has damages records from 0 to 8.

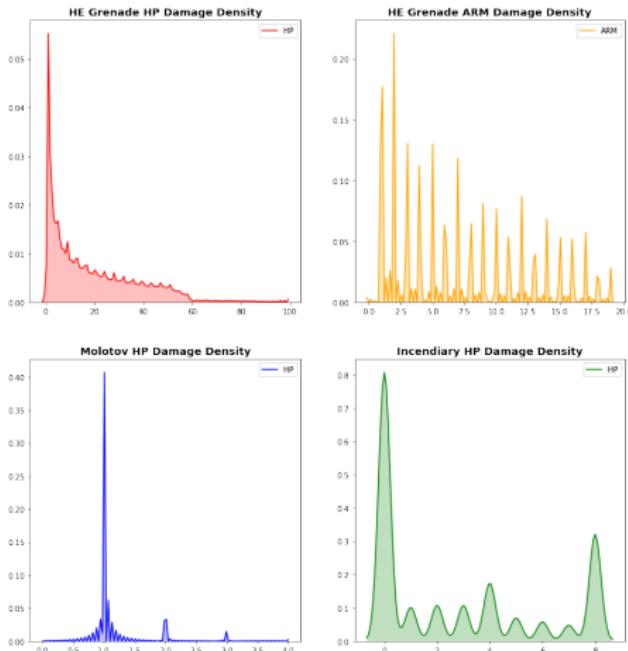


Fig. 4-32: Damage Density per Grenade

Locations of Grenades

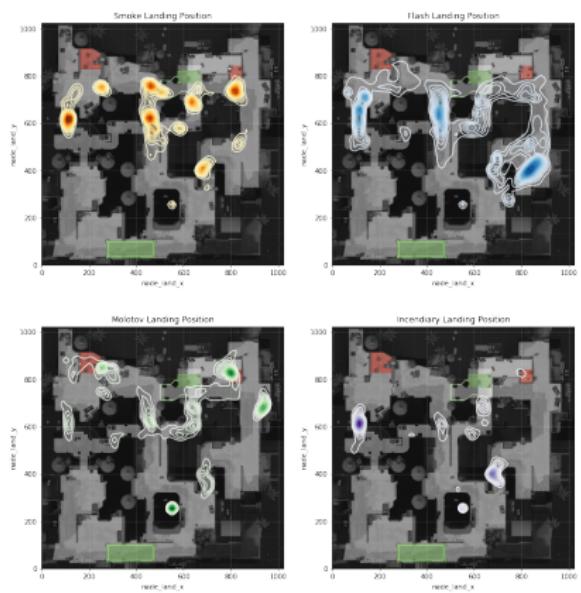


Fig. 4-33: Grenade locations on de_dust2

The landing places are basically fixed to several frequent position. Left is **Dust2** for example, **Mirage** & **Inferno** are listed below.

On the attacking side: The smoke often landed to the CT near A site, and the gate of B side. The Flash mostly in the A long, Molotov mostly fire on the car on the A site, break of B, and the inside of A.

On the defending side: smoke are landed to the tunnel of B, the central gate. The incendiaries for CT are mostly landed on the tunnel of B, the gate of A, short to A and the central gate.

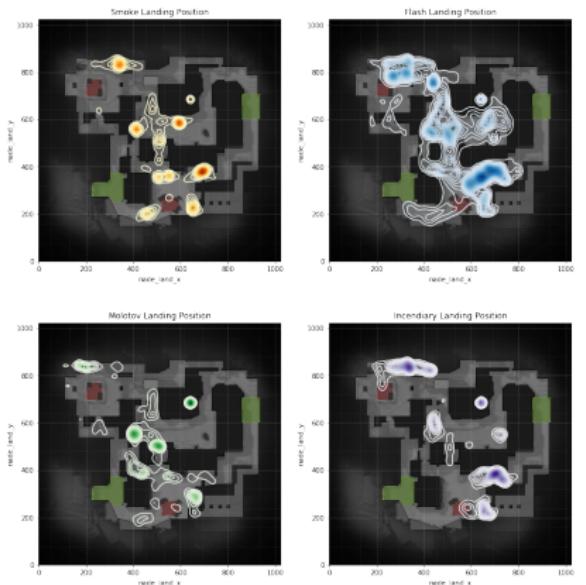


Fig. 4-34: Grenade locations on de_mirage

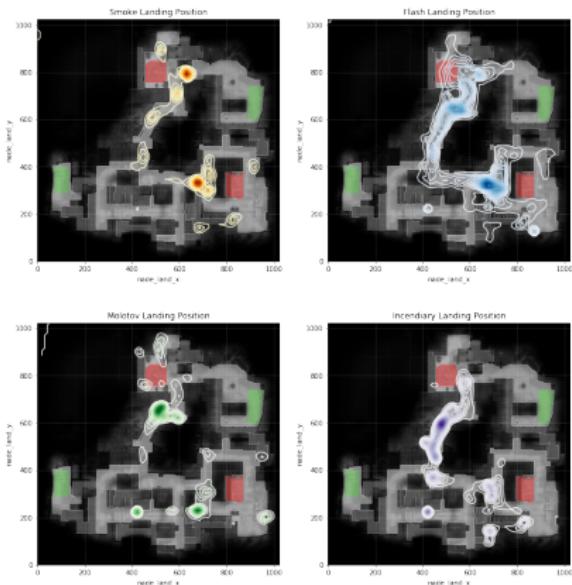


Fig. 4-35: Grenade locations on de_inferno

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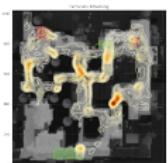
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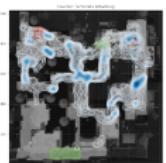
⑥ References

Heat Maps of attacking positions

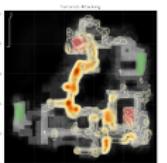
The heatmaps of frequent attacking positions on different maps are shown as Fig. 4-36, orange lines stand for T, and blue for CT. The depth of the color indicates the frequency of attack points.



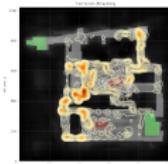
(a) Dust2



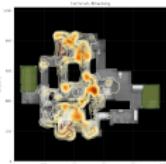
(b) Mirage



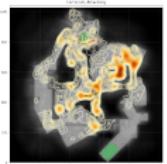
(c) Inferno



(d) Train



(e) Cache



(f) Overpass

Fig. 4-36: Frequency Heatmaps of Duty Maps

Overall Winning Chances

Most map are relatively balanced, *Nuke* is most tend to CT, and *Dus2* is most tend to T side, *Mirage* seems is the most balanced map.

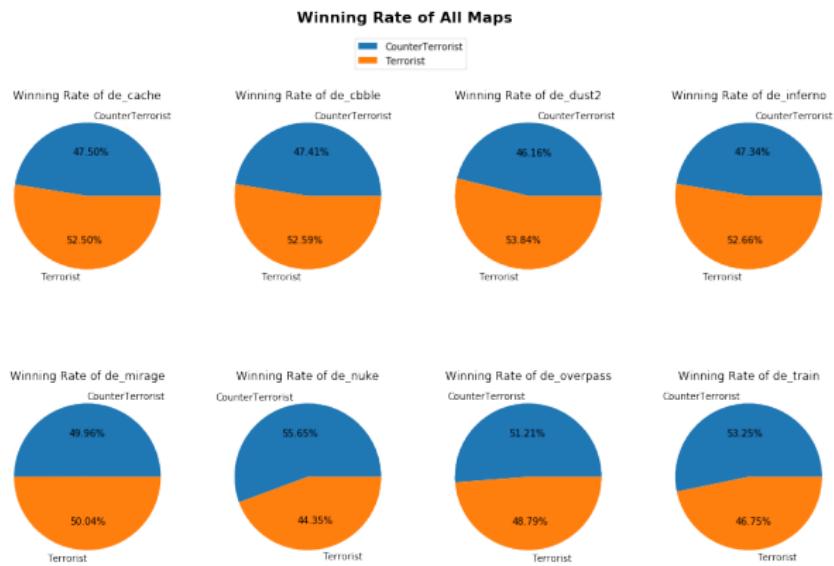


Fig. 4-37: Overall map winning chances

Winning Chances of Bomb Planting

The winning rate is 6 times higher after planting the bomb, and for the CT side, winning chance just makes less than 20% higher when Terrorists don't have chances to plant bomb.(Fig. 4-38)

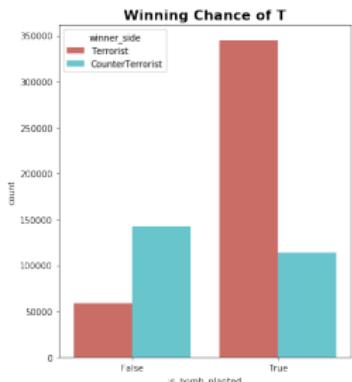


Fig. 4-38: Winning Chances by Bomb Planting Situation

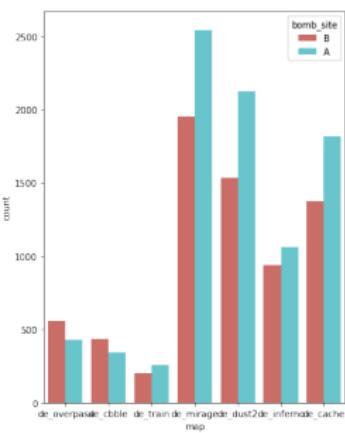


Fig. 4-39: Bomb Planting Counts

In *Mirage*, *Dust2* and *Cache*, planting at bomb site A a significant increase in win rate. Others can not be regarded as conclusions. (Fig. 4-39)

Winning chances of player advances of T

Nearly no winning round when have 3 players less, and have 20% of 2 players less, average at 45% of 1 player less. Average at 70% when equal. When having 1 more, it above 90%.

Table 4-3: Winning chances of player difference

XvX	map_bomb_site	count	de_cache	de_cobble	de_dust2	de_inferno	de_mirage	de_overpass	de_train
-3	A	16.666667	0.000000	18.750000	10.000000	4.545455	0.000000	0.000000	0.000000
	B	6.250000	33.333333	0.000000	0.000000	16.666667	0.000000	0.000000	0.000000
-2	A	17.567568	22.222222	27.536232	34.146341	27.027027	23.076923	11.111111	
	B	17.857143	16.666667	20.000000	44.186047	27.480916	21.428571	25.000000	
-1	A	44.696970	53.061224	47.826087	57.534247	41.284404	46.296296	36.000000	
	B	45.495495	45.454545	49.600000	50.370370	46.604938	40.000000	31.372549	
0	A	72.093023	68.539326	72.359155	75.666667	71.735791	65.178571	70.149254	
	B	73.958333	72.641509	71.794872	82.671480	74.368231	71.724138	59.649123	
1	A	88.888889	89.108911	89.126853	90.460526	90.558511	91.489362	93.750000	
	B	90.463215	89.510490	88.805970	93.560606	88.653846	86.585366	75.000000	
2	A	96.099291	98.333333	96.569921	97.905759	96.995708	98.360656	100.000000	
	B	95.141700	97.727273	96.825397	98.101266	97.967480	96.739130	87.500000	
3	A	100.000000	100.000000	100.000000	100.000000	99.367089	100.000000	100.000000	
	B	98.214286	100.000000	100.000000	100.000000	98.437500	100.000000	100.000000	
4	A	100.000000	100.000000	100.000000	100.000000	100.000000	100.000000	0.000000	
	B	100.000000	100.000000	100.000000	100.000000	100.000000	0.000000	0.000000	

ADR of different defending positions

Except the A site in Inferno, defending outside of bombsite will have a higher ADR, defending inside the bombsite usually have a negative ADR, which means being killed. So it will be wise to defending out of the bombsite after planted a bomb.

Table 4-4: ADR of different defending positions

att_callout map	A inner	B inner	N/A
de_cache	4.053875	8.481475	5.486609
de_cobble	-33.550420	6.402715	12.267927
de_dust2	-3.421429	5.076923	5.599861
de_inferno	11.939250	4.642857	8.242179
de_mirage	-1.317458	5.058519	7.965681
de_overpass	1.577273	-8.491991	4.336491
de_train	-16.496970	-7.260684	9.366601

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Conclusion

We mainly analyzed four part of the game mechanism and players behavior preferences.

Players tend to buy weapons that can almost kill in one hit, which also means good penetration, the most popular weapon in the CS:GO game is AK-47, the most popular pistol is Desert Eagle, these two weapon still caused most kills even in economic weak rounds.

The economics system is a great design to balance the difference of both sides due to the different characteristics of weapons. CT have to buy weapons more expensively, while T have more cheaper weapons with higher power. Higher economics leads to more winning chances, and more grenade using.

Grenades take a significant part in the game, reasonable and effective use of grenades will increase the probability of mastering the game and winning. High-Explosive grenades takes a mediocre place in game. Most locations of smoke, flash and fire grenades on both T & CT side are frequently fixed. The intent and method could be deduced and learned from grenade landing positions on different maps.

The duty maps are relatively balanced in winning chances. And the attacking and defending pattern could be seen from the heatmaps of frequent attacking positions. Plantting bombs have a great advantages in winning chances, and it is better to hold positions outside the bombsite to stop CT's returning.

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References

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Thanks!