Project Report

KNOWLEDGE & EXPERT SYSTEMS

Project Title	: Dota 2 – Hero Picker
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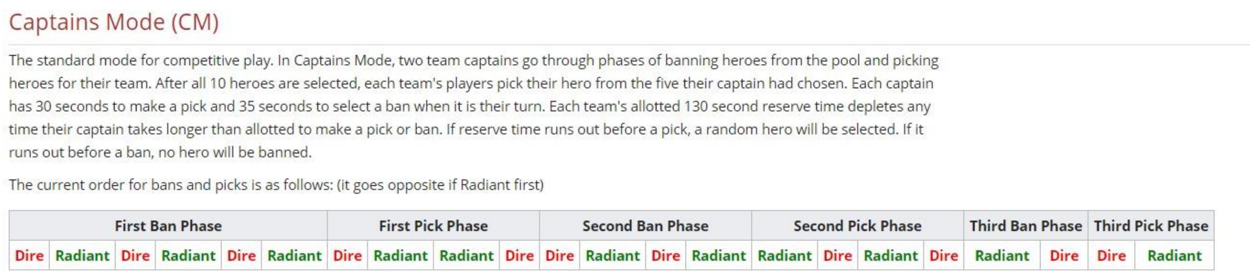
	Shemil Hashan (100768825)

PROBLEM STATEMENT

Dota 2 – MOBA PC GAME

It is a strategy game which is played by roughly 9 million users monthly. In competitive arenas, prize pools as high 34 million is awarded in grand stages. It is a 5 vs 5 game, 2 teams, where each team has to select 5 heroes out of 119 heroes in the pool with different skills. Same hero cannot be picked by both teams. Selection of these heroes directly supports the win probability.

We will specifically look into competitive professional mode of tournaments i.e. Captains Mode.



Captains Mode (CM)

The standard mode for competitive play. In Captains Mode, two team captains go through phases of banning heroes from the pool and picking heroes for their team. After all 10 heroes are selected, each team's players pick their hero from the five their captain had chosen. Each captain has 30 seconds to make a pick and 35 seconds to select a ban when it is their turn. Each team's allotted 130 second reserve time depletes any time their captain takes longer than allotted to make a pick or ban. If reserve time runs out before a pick, a random hero will be selected. If it runs out before a ban, no hero will be banned.

The current order for bans and picks is as follows: (it goes opposite if Radiant first)

First Ban Phase						First Pick Phase				Second Ban Phase				Second Pick Phase				Third Ban Phase		Third Pick Phase	
Dire	Radiant	Dire	Radiant	Dire	Radiant	Dire	Radiant	Radiant	Dire	Dire	Radiant	Dire	Radiant	Radiant	Dire	Radiant	Dire	Radiant	Dire	Dire	Radiant

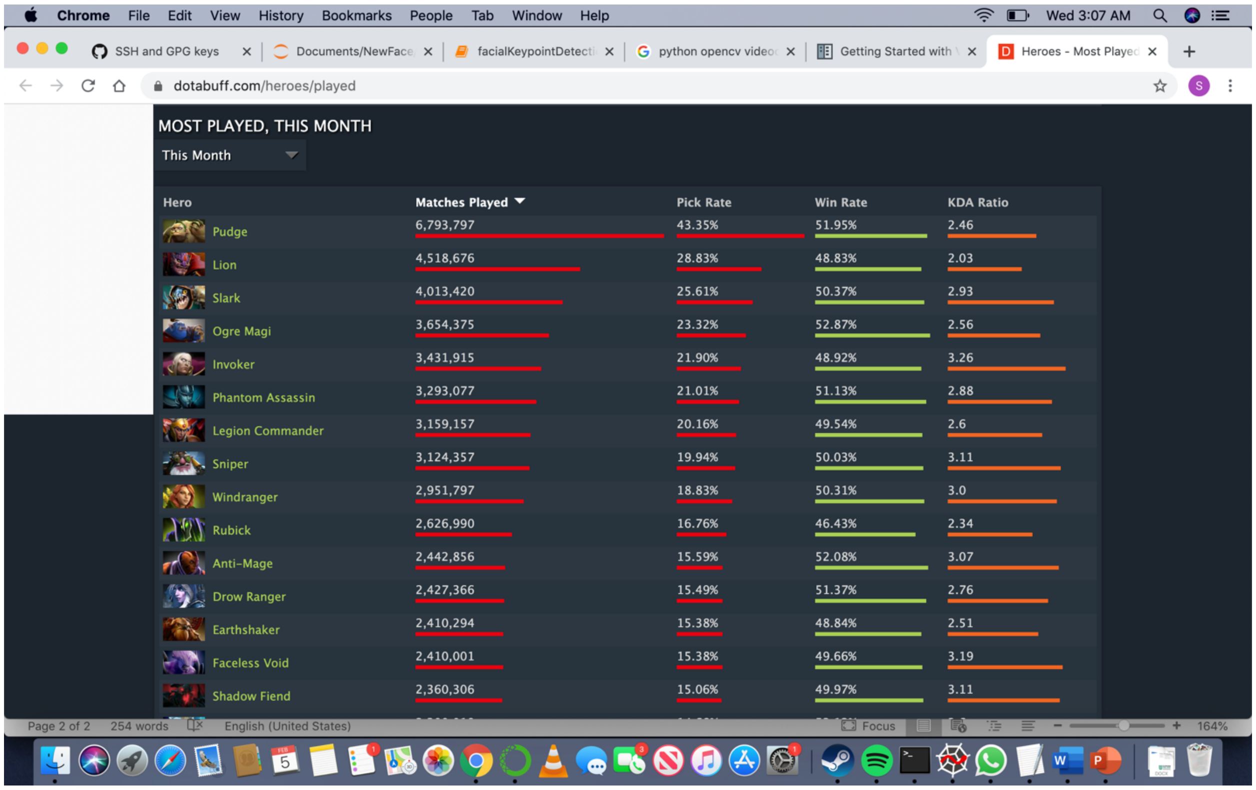
Ban Phase: Select heroes to be banned. Banned heroes cannot be picked. This done to prevent opponents from picking that hero because some heroes are weak against these heroes

Pick Phase: Pick the heroes you want to play

When you strategize the plan, it is important to ban heroes which will become a problem to our draft and pick strong heroes to win. Some of the hero skills combine to make powerful combos which can turn the course of events. Our expert system will help the users to decide which heroes to ban and pick. This analysis is critical and since there is a timer ticking for picks and bans, making the correct decisions fast is crucial.

DATA

Data: We have chosen dotabuff.com data as our knowledge extraction.
Overall win rates: https://www.dotabuff.com/heroes/played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SSH and GPG keys
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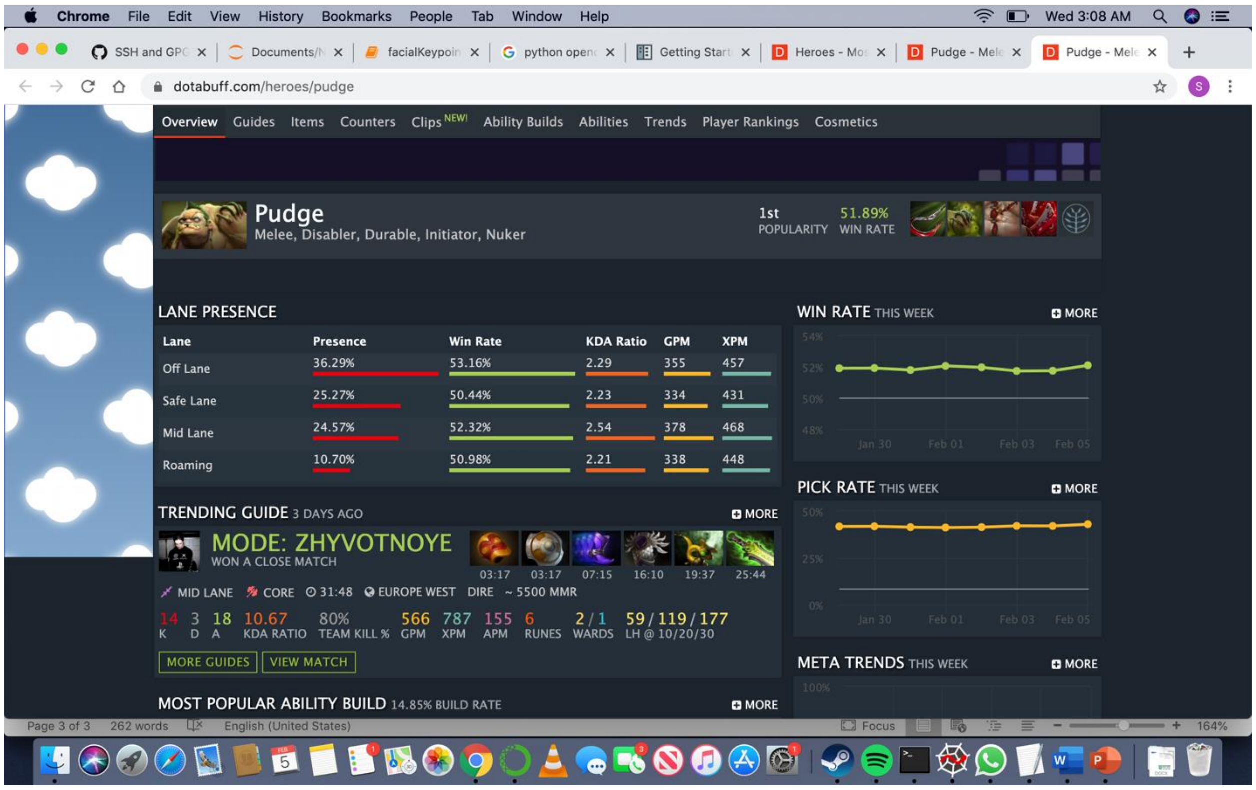
python opencv video
Getting Started with
Heroes - Most Played
dotabuff.com/heroes/played
Page 2 of 2 254 words English (United States)
Focus
164%

MOST PLAYED, THIS MONTH

This Month

Hero	Matches Played	Pick Rate	Win Rate	KDA Ratio
Pudge	6,793,797	43.35%	51.95%	2.46
Lion	4,518,676	28.83%	48.83%	2.03
Slark	4,013,420	25.61%	50.37%	2.93
Ogre Magi	3,654,375	23.32%	52.87%	2.56
Invoker	3,431,915	21.90%	48.92%	3.26
Phantom Assassin	3,293,077	21.01%	51.13%	2.88
Legion Commander	3,159,157	20.16%	49.54%	2.6
Sniper	3,124,357	19.94%	50.03%	3.11
Windranger	2,951,797	18.83%	50.31%	3.0
Rubick	2,626,990	16.76%	46.43%	2.34
Anti-Mage	2,442,856	15.59%	52.08%	3.07
Drow Ranger	2,427,366	15.49%	51.37%	2.76
Earthshaker	2,410,294	15.38%	48.84%	2.51
Faceless Void	2,410,001	15.38%	49.66%	3.19
Shadow Fiend	2,360,306	15.06%	49.97%	3.11

Single hero stats: Example Hero – Pudge - https://www.dotabuff.com/heroes/pudge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dotabuff.com/heroes/pudge
Overview Guides Items Counters Clips NEW! Ability Builds Abilities Trends Player Rankings Cosmetics

Pudge
Melee, Disabler, Durable, Initiator, Nuker

1st POPULARITY 51.89% WIN RATE

LANE PRESENCE

Lane	Presence	Win Rate	KDA Ratio	GPM	XPM
Off Lane	36.29%	53.16%	2.29	355	457
Safe Lane	25.27%	50.44%	2.23	334	431
Mid Lane	24.57%	52.32%	2.54	378	468
Roaming	10.70%	50.98%	2.21	338	448

WIN RATE THIS WEEK MORE

PICK RATE THIS WEEK MORE

TRENDING GUIDE 3 DAYS AGO MORE

MODE: ZHYVOTNOYE
WON A CLOSE MATCH
03:17 03:17 07:15 16:10 19:37 25:44
MID LANE CORE 31:48 EUROPE WEST DIRE ~5500 MMR

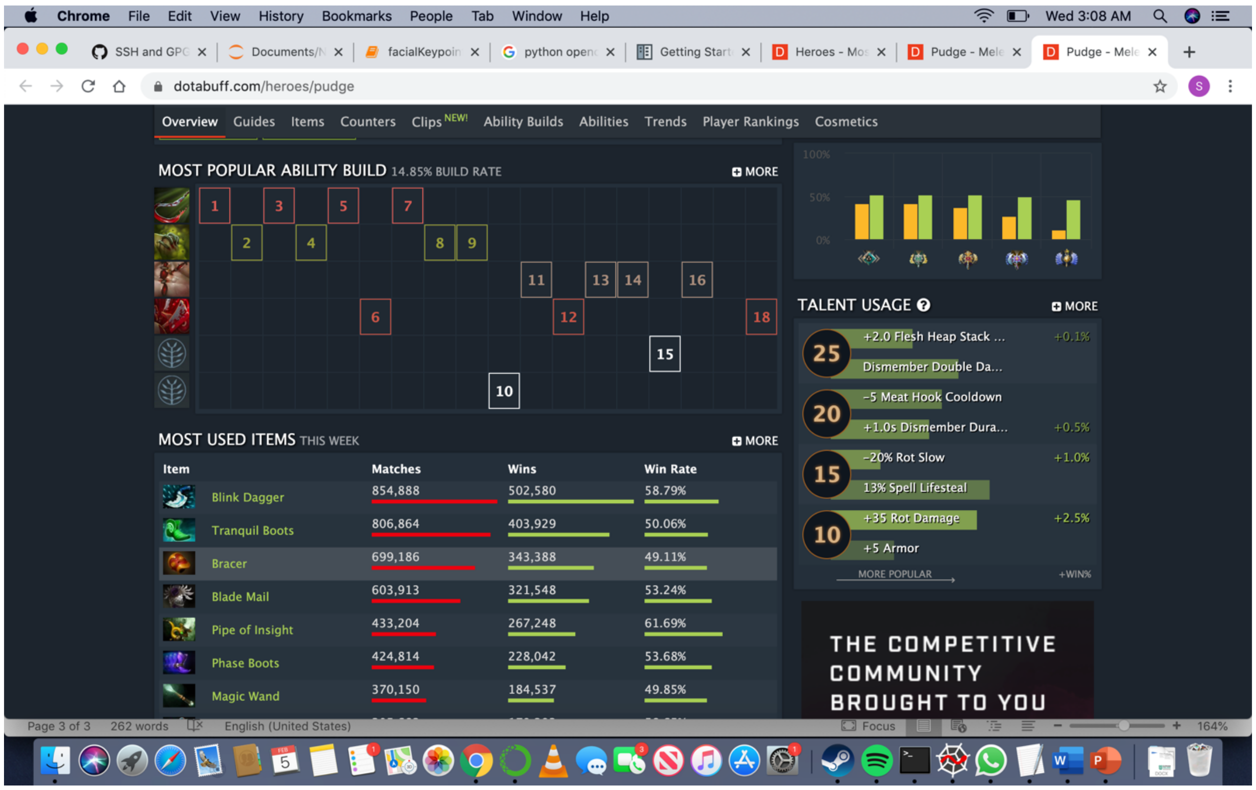
14	3	18	10.67	80%	566	787	155	6	2 / 1	59 / 119 / 177
K	D	A	KDA RATIO	TEAM KILL %	GPM	XPM	APM	RUNES	WARDS	LH @ 10/20/30

MORE GUIDES VIEW MATCH

META TRENDS THIS WEEK MORE

MOST POPULAR ABILITY BUILD 14.85% BUILD RATE MORE

Page 3 of 3 262 words English (United States) Focus 164%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MOST POPULAR ABILITY BUILD 14.85% BUILD RATE MORE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 18

TALENT USAGE MORE

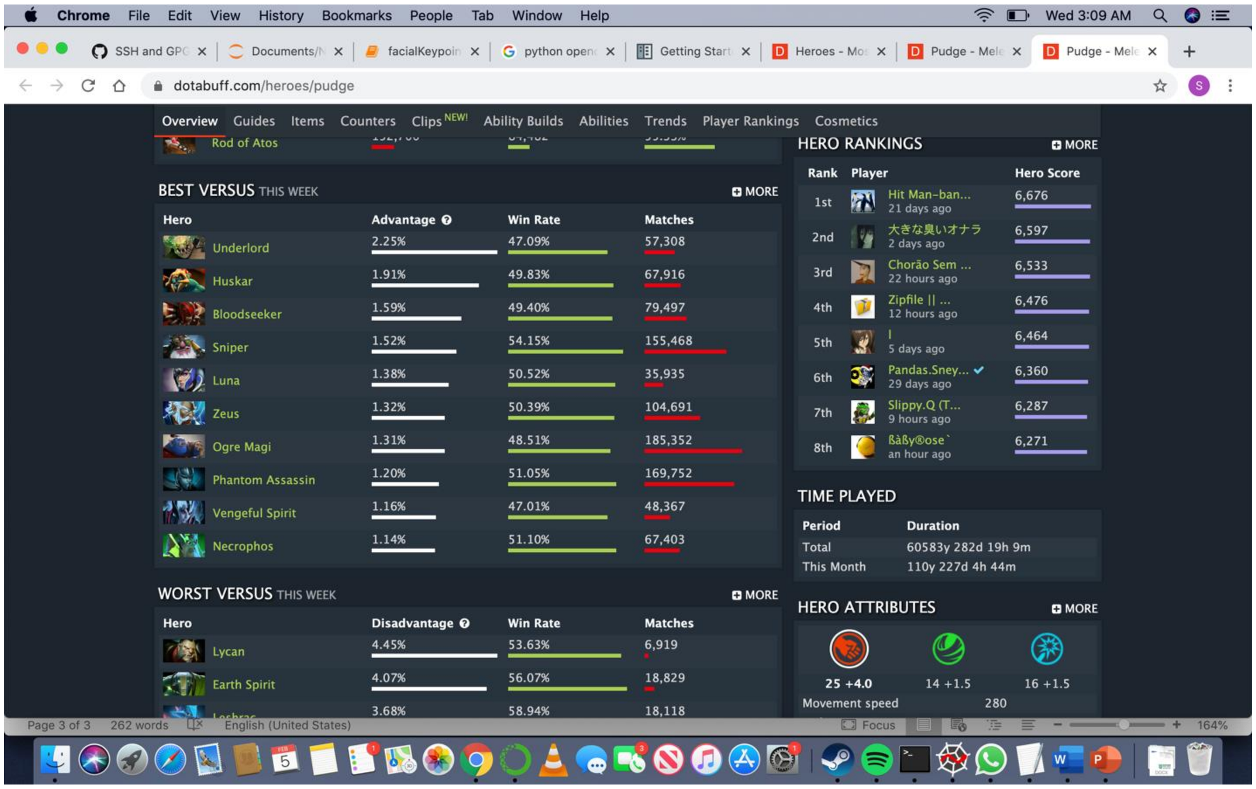
Level	Left	Right
25	+2.0 Flesh Heap Stack ...	Dismember Double Da...
20	-5 Meat Hook Cooldown	+1.0s Dismember Dura...
15	-20% Rot Slow	13% Spell Lifesteal
10	+35 Rot Damage	+5 Armor

+0.1% +0.5% +1.0% +2.5%
MORE POPULAR +WIN%

MOST USED ITEMS THIS WEEK MORE

Item	Matches	Wins	Win Rate
Blink Dagger	854,888	502,580	58.79%
Tranquil Boots	806,864	403,929	50.06%
Bracer	699,186	343,388	49.11%
Blade Mail	603,913	321,548	53.24%
Pipe of Insight	433,204	267,248	61.69%
Phase Boots	424,814	228,042	53.68%
Magic Wand	370,150	184,537	49.85%

THE COMPETITIVE COMMUNITY BROUGHT TO YOU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dotabuff.com/heroes/pudge
Overview Guides Items Counters Clips NEW! Ability Builds Abilities Trends Player Rankings Cosmetics
Rod of Atos
Page 3 of 3 262 words English (United States) Focus 164%

BEST VERSUS THIS WEEK

MORE

Hero	Advantage	Win Rate	Matches
Underlord	2.25%	47.09%	57,308
Huskar	1.91%	49.83%	67,916
Bloodseeker	1.59%	49.40%	79,497
Sniper	1.52%	54.15%	155,468
Luna	1.38%	50.52%	35,935
Zeus	1.32%	50.39%	104,691
Ogre Magi	1.31%	48.51%	185,352
Phantom Assassin	1.20%	51.05%	169,752
Vengeful Spirit	1.16%	47.01%	48,367
Necrophos	1.14%	51.10%	67,403

HERO RANKINGS

MORE

Rank	Player	Hero Score
1st	Hit Man-ban... 21 days ago	6,676
2nd	大きな臭いオナラ 2 days ago	6,597
3rd	Chorão Sem ... 22 hours ago	6,533
4th	Zipfile || ... 12 hours ago	6,476
5th	| 5 days ago	6,464
6th	Pandas.Sney... 29 days ago	6,360
7th	Slippy.Q (T... 9 hours ago	6,287
8th	ßåßy®ose` an hour ago	6,271

TIME PLAYED

Period	Duration
Total	60583y 282d 19h 9m
This Month	110y 227d 4h 44m

WORST VERSUS THIS WEEK

MORE

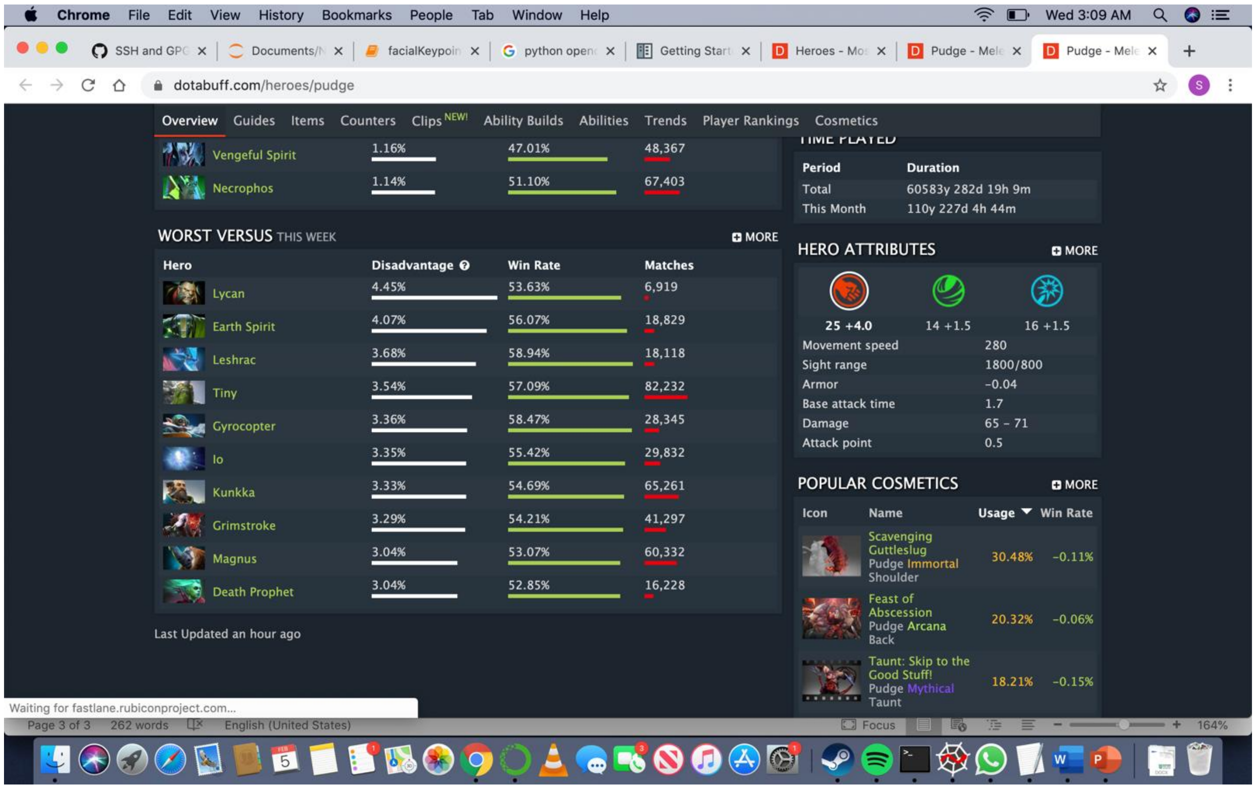
Hero	Disadvantage	Win Rate	Matches
Lycan	4.45%	53.63%	6,919
Earth Spirit	4.07%	56.07%	18,829
Leshrac	3.68%	58.94%	18,118

HERO ATTRIBUTES

MORE

25 +4.0 14 +1.5 16 +1.5

Movement speed 280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Page 3 of 3 262 words English (United States) Focus 164%

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Necrophos	1.14%	51.10%	67,403

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WORST VERSUS THIS WEEK

MORE

Hero	Disadvantage	Win Rate	Matches
Lycan	4.45%	53.63%	6,919
Earth Spirit	4.07%	56.07%	18,829
Leshrac	3.68%	58.94%	18,118
Tiny	3.54%	57.09%	82,232
Gyrocopter	3.36%	58.47%	28,345
Io	3.35%	55.42%	29,832
Kunkka	3.33%	54.69%	65,261
Grimstroke	3.29%	54.21%	41,297
Magnus	3.04%	53.07%	60,332
Death Prophet	3.04%	52.85%	16,228

Last Updated an hour ago

HERO ATTRIBUTES

MORE

25 +4.0 14 +1.5 16 +1.5

Movement speed	280
Sight range	1800/800
Armor	-0.04
Base attack time	1.7
Damage	65 - 71
Attack point	0.5

POPULAR COSMETICS

MORE

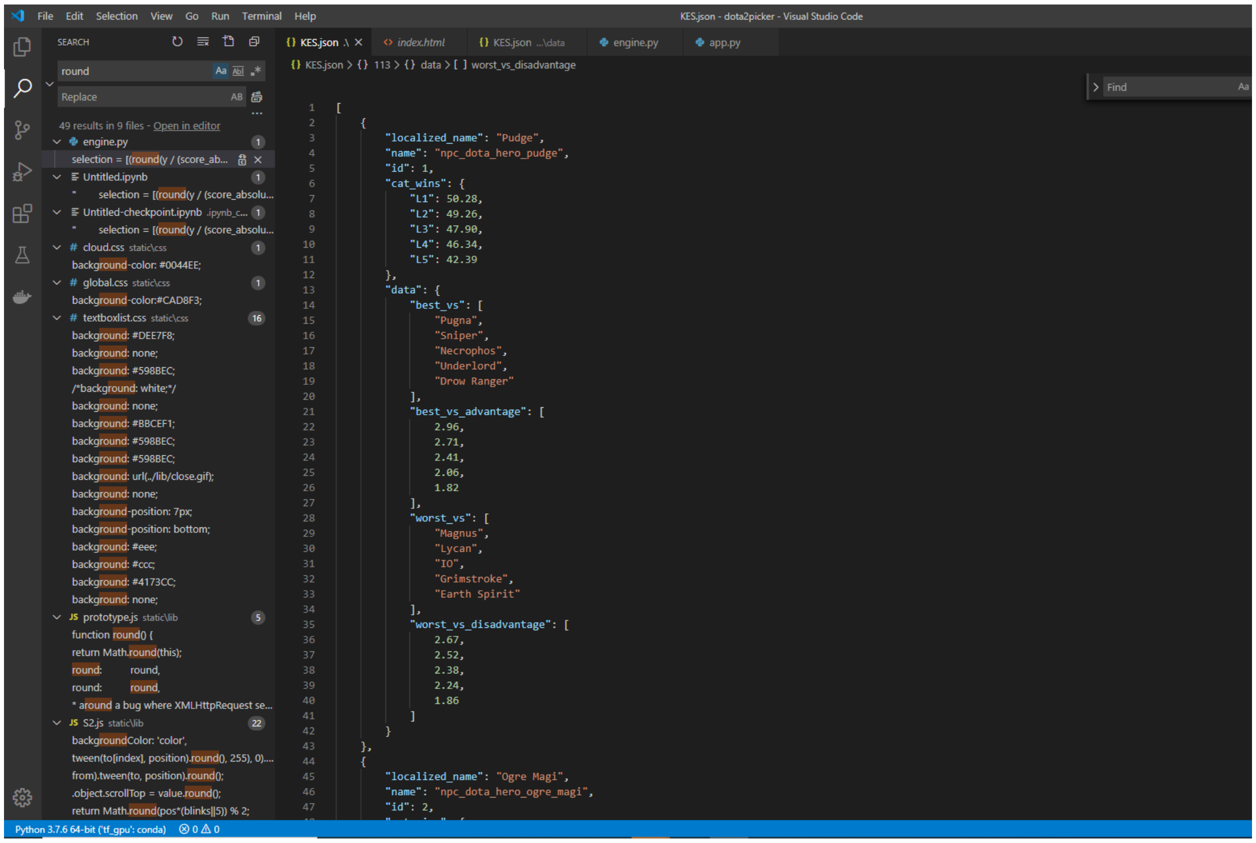
Icon	Name	Usage	Win Rate
	Scavenging Guttleslug Pudge Immortal Shoulder	30.48%	-0.11%
	Feast of Abscession Pudge Arcana Back	20.32%	-0.06%
	Taunt: Skip to the Good Stuff! Pudge Mythical Taunt	18.21%	-0.15%

With these data of Best Versus and Worst versus, we can create an expert systems to suggest the next pick or ban.

IMPLEMENTATION

ARRANGE DATA

All data in current Meta section is arranged as JSON file.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KES.json - dota2picker - Visual Studio Code
SEARCH
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KES.json .\
index.html
KES.json ...\data
engine.py
app.py
KES.json > {} 113 > {} data > [ ] worst_vs_disadvantage
Find
Python 3.7.6 64-bit ('tf_gpu': conda)
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```
49 results in 9 files - Open in editor
engine.py  1
    selection = [(round(y / (score_ab...
Untitled.ipynb  1
    "       selection = [(round(y / (score_absolu...
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    "       selection = [(round(y / (score_absolu...
cloud.css static\css  1
    background-color: #0044EE;
global.css static\css  1
    background-color:#CAD8F3;
textboxlist.css static\css  16
    background: #DEE7F8;
    background: none;
    background: #598BEC;
    /*background: white;*/
    background: none;
    background: #BBCEF1;
    background: #598BEC;
    background: #598BEC;
    background: url(../lib/close.gif);
    background: none;
    background-position: 7px;
    background-position: bottom;
    background: #eee;
    background: #ccc;
    background: #4173CC;
    background: none;
prototype.js static\lib  5
    function round() {
    return Math.round(this);
    round:        round,
    round:        round,
    * around a bug where XMLHttpRequest se...
S2.js static\lib  22
    backgroundColor: 'color',
    tween(to[index], position).round(), 255), 0)....
    from).tween(to, position).round();
    .object.scrollTop = value.round();
    return Math.round(pos*(blinks||5)) % 2;
```

```
[
    {
        "localized_name": "Pudge",
        "name": "npc_dota_hero_pudge",
        "id": 1,
        "cat_wins": {
            "L1": 50.28,
            "L2": 49.26,
            "L3": 47.90,
            "L4": 46.34,
            "L5": 42.39
        },
        "data": {
            "best_vs": [
                "Pugna",
                "Sniper",
                "Necrophos",
                "Underlord",
                "Drow Ranger"
            ],
            "best_vs_advantage": [
                2.96,
                2.71,
                2.41,
                2.06,
                1.82
            ],
            "worst_vs": [
                "Magnus",
                "Lycan",
                "IO",
                "Grimstroke",
                "Earth Spirit"
            ],
            "worst_vs_disadvantage": [
                2.67,
                2.52,
                2.38,
                2.24,
                1.86
            ]
        }
    },
    {
        "localized_name": "Ogre Magi",
        "name": "npc_dota_hero_ogre_magi",
        "id": 2,
```

Localized_name / caption - displaying purpose

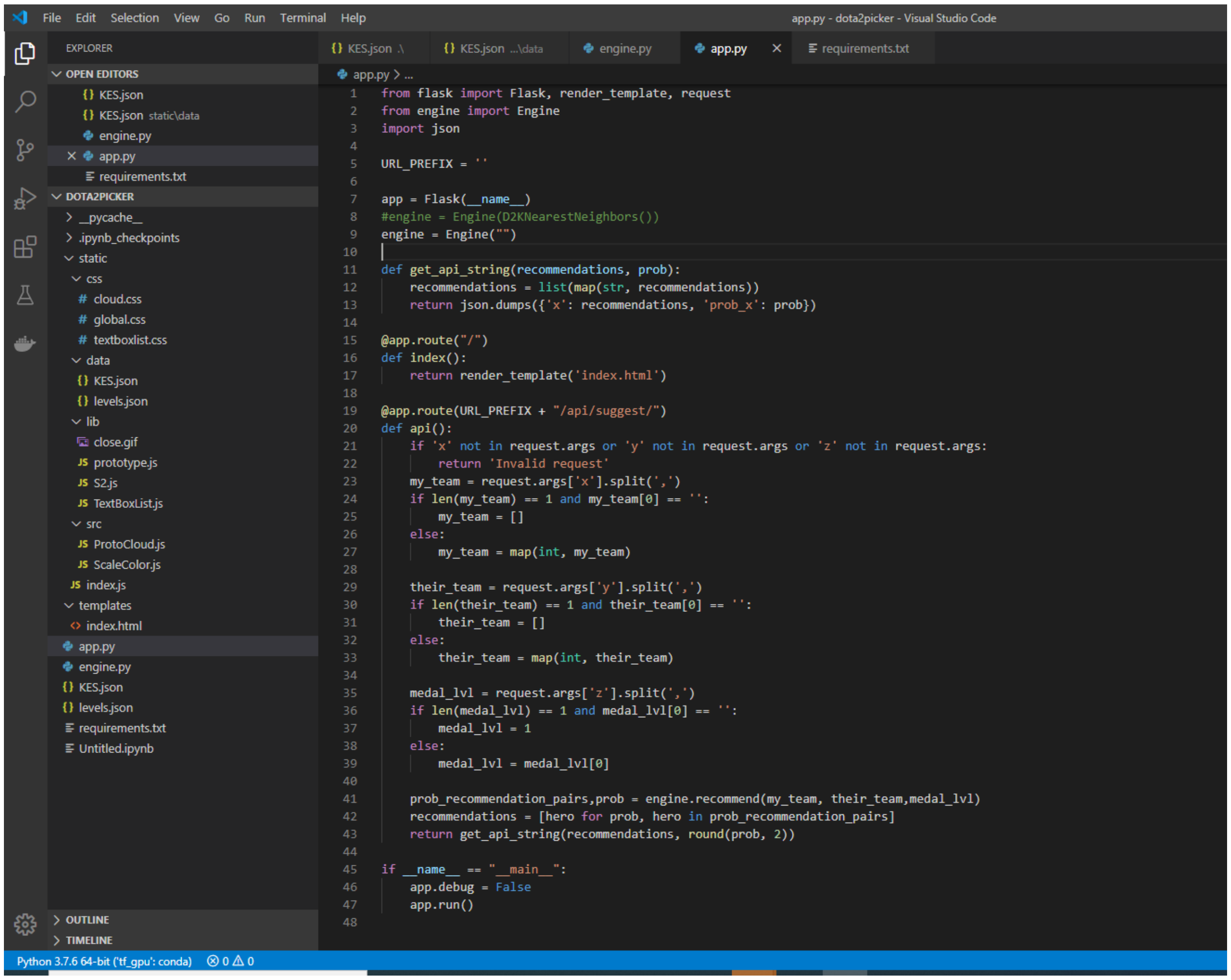
Name – unique id string

Cat_wins – win percentage for each skill category

Data – best_vs – which heroes this particular hero is best against
best_vs_advantage – percentage advantage over relevant hero
worst_vs – heroes weak against
worst_vs_disadvantage – percentage disadvantage

This JSON file is our Knowledge Base to be used for selection criteria.

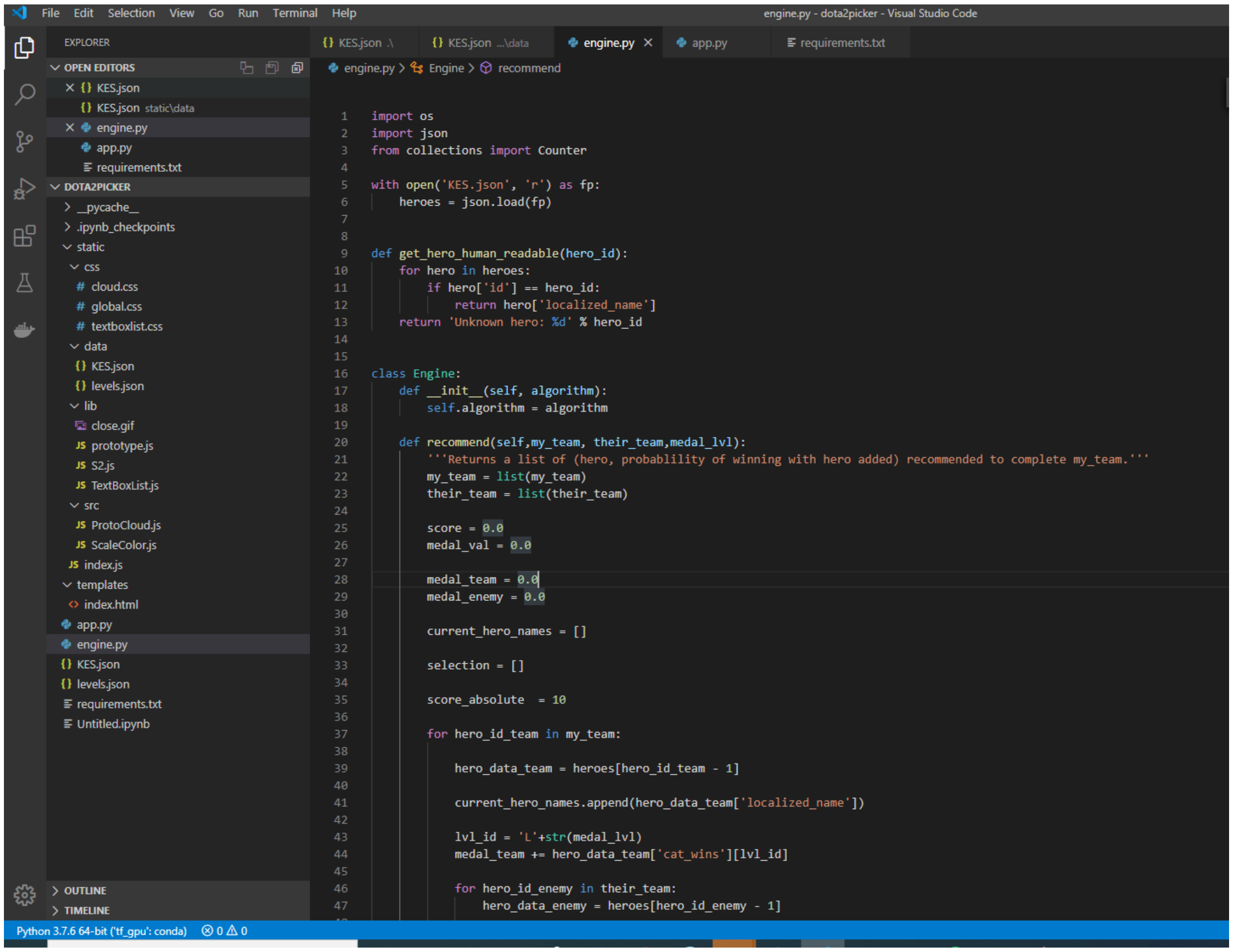
APP



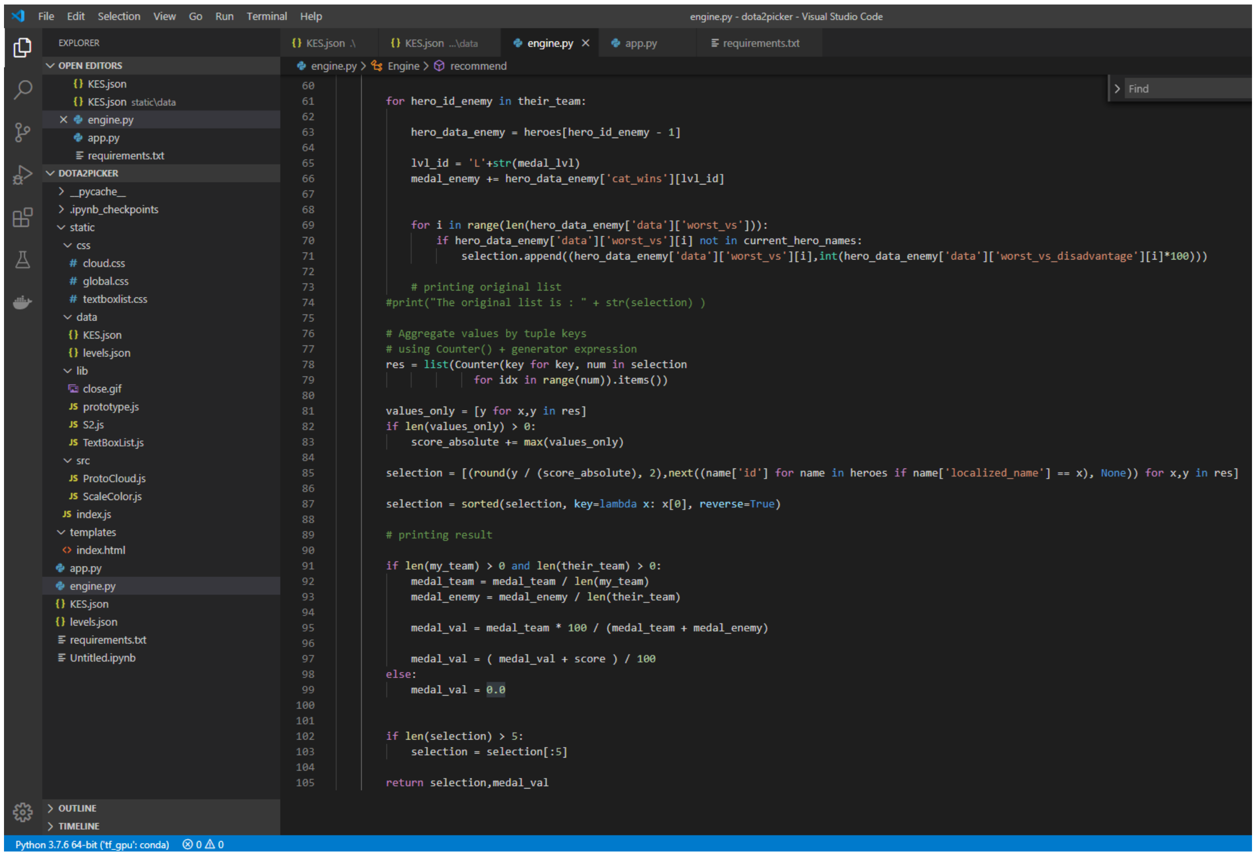
```python
from flask import Flask, render_template, request
from engine import Engine
import json

URL_PREFIX = ''

app = Flask(__name__)
#engine = Engine(D2KNearestNeighbors())
engine = Engine("")

def get_api_string(recommendations, prob):
    recommendations = list(map(str, recommendations))
    return json.dumps({'x': recommendations, 'prob_x': prob})

@app.route("/")
def index():
    return render_template('index.html')

@app.route(URL_PREFIX + "/api/suggest/")
def api():
    if 'x' not in request.args or 'y' not in request.args or 'z' not in request.args:
        return 'Invalid request'
    my_team = request.args['x'].split(',')
    if len(my_team) == 1 and my_team[0] == '':
        my_team = []
    else:
        my_team = map(int, my_team)

    their_team = request.args['y'].split(',')
    if len(their_team) == 1 and their_team[0] == '':
        their_team = []
    else:
        their_team = map(int, their_team)

    medal_lvl = request.args['z'].split(',')
    if len(medal_lvl) == 1 and medal_lvl[0] == '':
        medal_lvl = 1
    else:
        medal_lvl = medal_lvl[0]

    prob_recommendation_pairs,prob = engine.recommend(my_team, their_team,medal_lvl)
    recommendations = [hero for prob, hero in prob_recommendation_pairs]
    return get_api_string(recommendations, round(prob, 2))

if __name__ == "__main__":
    app.debug = False
    app.run()
```

We have created the application hosting with Flask. In the root route it will present an HTML file for the UI. When a selection happens, /api/suggest route is called to get the recommendations with win probability. When the values are returned, UI is updated. Java Scripts are used to handle web page data and functionality. Index.html is UI and index.js controls UI functionality. We created an instance of Engine to call the recommendation function.

ENGINE



```python
import os
import json
from collections import Counter

with open('KES.json', 'r') as fp:
    heroes = json.load(fp)


def get_hero_human_readable(hero_id):
    for hero in heroes:
        if hero['id'] == hero_id:
            return hero['localized_name']
    return 'Unknown hero: %d' % hero_id


class Engine:
    def __init__(self, algorithm):
        self.algorithm = algorithm

    def recommend(self,my_team, their_team,medal_lvl):
        '''Returns a list of (hero, probablility of winning with hero added) recommended to complete my_team.'''
        my_team = list(my_team)
        their_team = list(their_team)

        score = 0.0
        medal_val = 0.0

        medal_team = 0.0
        medal_enemy = 0.0

        current_hero_names = []

        selection = []

        score_absolute  = 10

        for hero_id_team in my_team:

            hero_data_team = heroes[hero_id_team - 1]

            current_hero_names.append(hero_data_team['localized_name'])

            lvl_id = 'L'+str(medal_lvl)
            medal_team += hero_data_team['cat_wins'][lvl_id]

            for hero_id_enemy in their_team:
                hero_data_enemy = heroes[hero_id_enemy - 1]
```



```python
        for hero_id_enemy in their_team:

            hero_data_enemy = heroes[hero_id_enemy - 1]

            lvl_id = 'L'+str(medal_lvl)
            medal_enemy += hero_data_enemy['cat_wins'][lvl_id]


            for i in range(len(hero_data_enemy['data']['worst_vs'])):
                if hero_data_enemy['data']['worst_vs'][i] not in current_hero_names:
                    selection.append((hero_data_enemy['data']['worst_vs'][i],int(hero_data_enemy['data']['worst_vs_disadvantage'][i]*100)))

            # printing original list
        #print("The original list is : " + str(selection) )

        # Aggregate values by tuple keys
        # using Counter() + generator expression
        res = list(Counter(key for key, num in selection
                    for idx in range(num)).items())

        values_only = [y for x,y in res]
        if len(values_only) > 0:
            score_absolute += max(values_only)

        selection = [(round(y / (score_absolute), 2),next((name['id'] for name in heroes if name['localized_name'] == x), None)) for x,y in res]

        selection = sorted(selection, key=lambda x: x[0], reverse=True)

        # printing result

        if len(my_team) > 0 and len(their_team) > 0:
            medal_team = medal_team / len(my_team)
            medal_enemy = medal_enemy / len(their_team)

            medal_val = medal_team * 100 / (medal_team + medal_enemy)

            medal_val = ( medal_val + score ) / 100
        else:
            medal_val = 0.0


        if len(selection) > 5:
            selection = selection[:5]

        return selection,medal_val
```

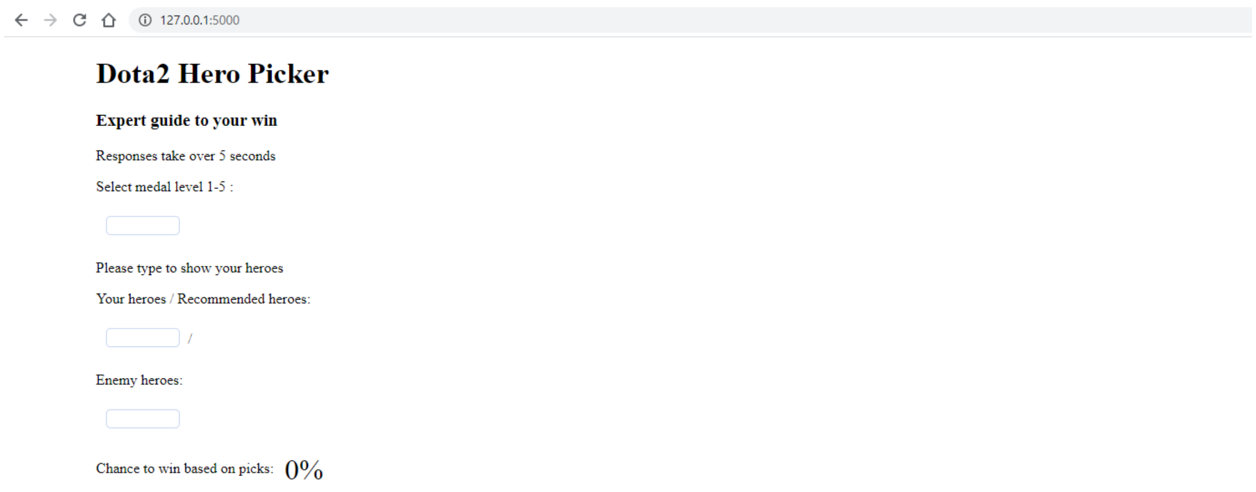
It initially loads all data of 120 heroes. Then when recommend function is called with ids of my team, enemy team and medal level. We iterate through my team and nested inside for enemy team. Our current selection hero medal values are aggregated together while enemies aggregated separately. Then average is taken for consideration as maximum is not the correct win rate neither minimum. Also, some heroes average less than 50% win rate. In case best is taking my team and enemy team ratio as a percentage for base win rate.

While iterating we check if my team has heroes which are good against enemy current selection, if it exists, positive reward of advantage value is added to win percentage. If our selection has weak heroes against enemy selections, disadvantage value is deducted from win percentage as a negative reward. So the win percentage is calculated with that.

Then we have considered which heroes are best against enemy team with enemy team data worst_vs. Then they are pooled together followed by aggregating values for each hero then divided by a value larger than max + constant of current advantage aggregates. Then sorted for maximum of that value. Then best up to 5 is selected as recommended.

So, both recommend hero ids and win rate is sent back to app to update.

GUI


127.0.0.1:5000

Dota2 Hero Picker

Expert guide to your win

Responses take over 5 seconds

Select medal level 1-5 :

Please type to show your heroes

Your heroes / Recommended heroes:

/

Enemy heroes:

Chance to win based on picks: 0%

First box is to select level. Dota 2 rank medals Herald, Guardian, Crusader falls under 1. Archon 2, Legend 3, Ancient 4, Diving and Immortal is 5. It is the first selection to make.

Then can choose our team or enemy selection. If we select ours first, no recommendation is given since enemies not filled. If enemy is selected, recommended list is populated. We have to type and make more selections. Based on our selection win percentage and recommendations change. If we have not picked any hero, it will stay at 0.

DEMO

Step 1: Open a terminal, go to project folder.

Step 2: `pip install -r requirements.txt`

This install all required python libraries to run

Step 3: python app.py

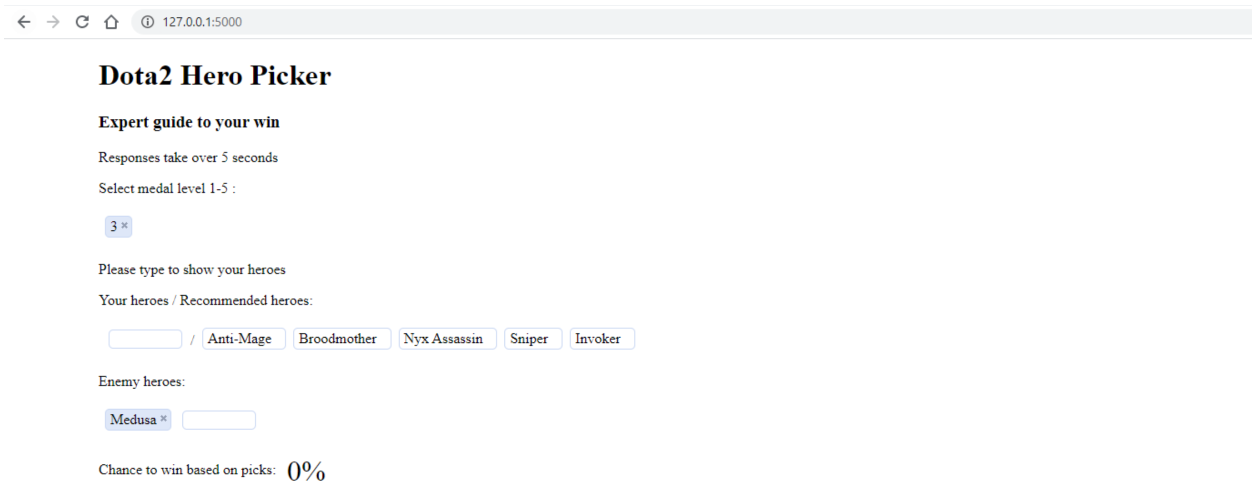
This will start the server run

Step 4: Open a browser and go to 127.0.0.1:5000 , index page will be loaded

Step 5: Make the medal level selection by typing 1 – 5 and select option.

Step 6: Enjoy selecting heroes by typing hero names, list will be shown to click and select.

Example Demo



127.0.0.1:5000

Dota2 Hero Picker

Expert guide to your win

Responses take over 5 seconds

Select medal level 1-5 :

3 ×

Please type to show your heroes

Your heroes / Recommended heroes:

/ Anti-Mage Broodmother Nyx Assassin Sniper Invoker

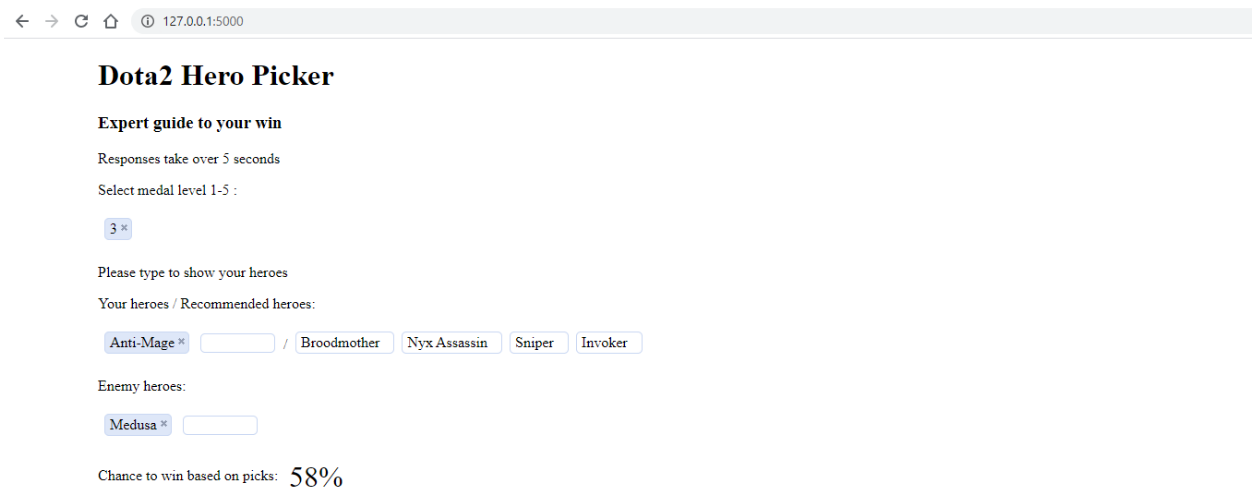
Enemy heroes:

Medusa ×

Chance to win based on picks: 0%

Figure 1

Figure 1 shows selection of medal as 3. Then enemy Medusa is selected. So the recommendations pop up with Anti-Mage, Broodmother, etc. Since we current picked no hero, win rate is 0.



127.0.0.1:5000

Dota2 Hero Picker

Expert guide to your win

Responses take over 5 seconds

Select medal level 1-5 :

3

Please type to show your heroes

Your heroes / Recommended heroes:

Anti-Mage / Broodmother Nyx Assassin Sniper Invoker

Enemy heroes:

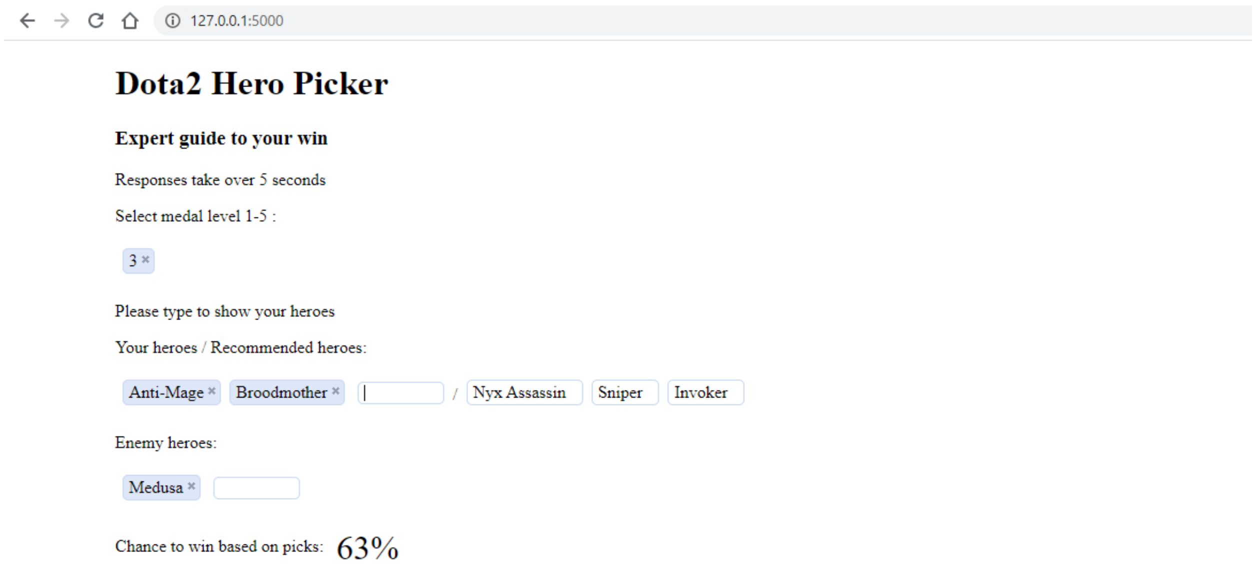
Medusa

Chance to win based on picks: 58%

Figure 2

So we make recommended hero Anti-Mage, win percentage shows as 58% and that option is removed from recommended.

Fi


127.0.0.1:5000

Dota2 Hero Picker

Expert guide to your win

Responses take over 5 seconds

Select medal level 1-5 :

3 ×

Please type to show your heroes

Your heroes / Recommended heroes:

Anti-Mage × Broodmother × / Nyx Assassin Sniper Invoker

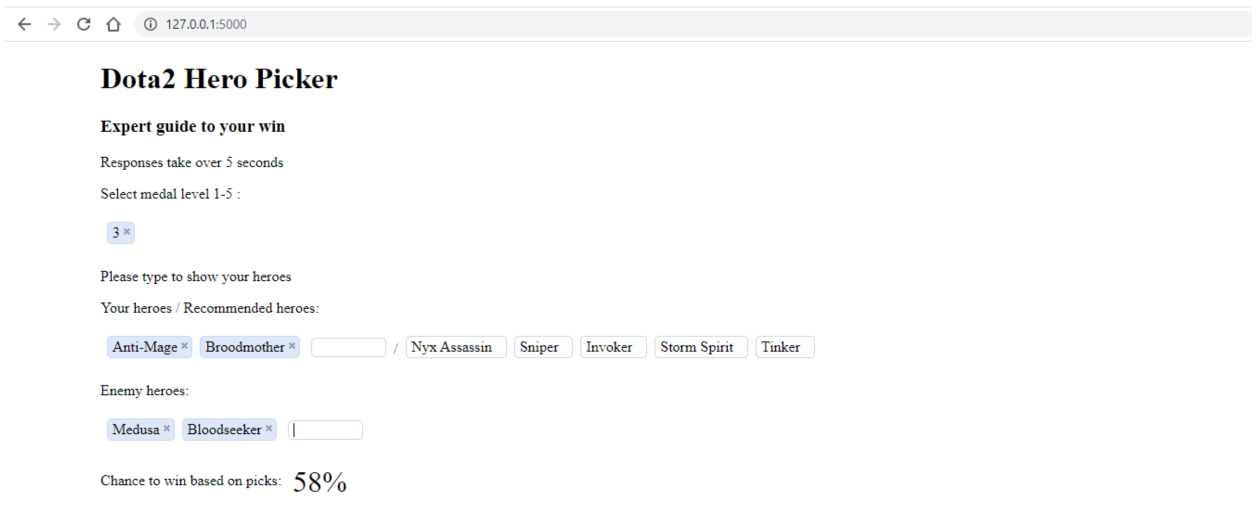
Enemy heroes:

Medusa ×

Chance to win based on picks: 63%

Figure 3

Now we take another suggestion as Broodmother, results in increasing win percentage because both are good against Medusa.



127.0.0.1:5000

Dota2 Hero Picker

Expert guide to your win

Responses take over 5 seconds

Select medal level 1-5 :

3

Please type to show your heroes

Your heroes / Recommended heroes:

Anti-Mage, Broodmother / Nyx Assassin, Sniper, Invoker, Storm Spirit, Tinker

Enemy heroes:

Medusa, Bloodseeker

Chance to win based on picks: 58%

Figure 4

Now enemy picks a good counter pick for Anti-Mage, Bloodseeker . So the win percentage goes down significantly.

FUTURE IMPROVEMENTS

We have taken data from a frozen time, but these data change rapidly when a new large update come in for Dota, usually once in 3 to 4 months. So, we have to automate the data gathering part for this to work properly.

Also, UI can be improved significantly to cater the player with a good user experience.

If we get chance to analyze each player in my team with their game history, we can improve the recommendation to tailor the players. Dota has an API to get player match data, but it is a bit complex integration which requires high processing power to analyze thousands of games.

CONCLUSION

We did not employ a full algorithm from the course but we took the idea of reward and penalty for the suggestion with our own algorithm for selection criteria and calculation. Our final product works on par with our expected level.