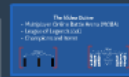


# Linear Programming for MOBA Strategy Video Games



### Linear Programming


- Built-in MATLAB
- Inprog and Intling
- Simple Method function
- (examples)
- Other Methods?



# Linear Programming for MOBA Strategy Video Games


**The Video Game**

- Multiplayer Online Battle Arena (MOBA)
- League of Legends (LoL)
- Champions and Items



**Linear Programming**

- Built-In MATLAB *linprog* and *intlinprog*
- Simplex Method function *lpsimplex.m*
- Other Methods?



**Data and Optimization Problem**

Champion	Health	Mana	Attack	Defense	Speed	Cost
A	1000	100	10	10	10	1000
B	1000	100	10	10	10	1000
C	1000	100	10	10	10	1000


The optimization problem is to find the maximum value of the objective function  $Z = 1000x_1 + 1000x_2 + 1000x_3$  subject to the constraints  $Ax \leq b$  and  $x \geq 0$ .

**Results**



**Outputs**

The outputs from our functions for all three champions.



**Inputs**

The function calls require f, A, b.

champs = 'A';  
b = [1000; 100; 10; 10; 10; 1000];

champs = 'B';  
b = [1000; 100; 10; 10; 10; 1000];

champs = 'C';  
b = [1000; 100; 10; 10; 10; 1000];

f is the cost of gold for each item which is "fit" around the data shown in the previous slide.

A is the remainder of the data which is costs of each item.

# *Linear Programming*

- Built-In MATLAB

*linprog and intlinprog*

- Simplex Method function

- • *lpsimplex.m*

- Other Methods?

## *Other Methods*

We looked into a multitude of other methods such as:

- Big M method
  - when a constraint has different inequality
- Dual Simplex Method
  - when a variable has a different inequality

But these didnt fit what we needed from our optimization process so we used linprog, intlinprog and lpsimplex

## *Other Methods*

We looked into a multitude of other methods such as:

- Big M method
  - when a constraint has different inequality
- Dual Simplex Method
  - when a variable has a different inequality

But these didnt fit what we needed from our optimization process so we used linprog, intlinprog and lpsimplex

# The Video Game

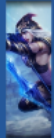
- Multiplayer Online Battle Arena (MOBA)
- League of Legends (LoL)
- Champions and Items

## Champions

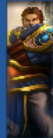
Champions Used in Project

We used 3 that are the best for beginning players

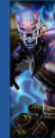
• Ashe



• Garen



• Ryze



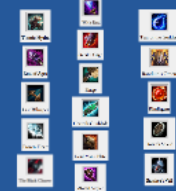
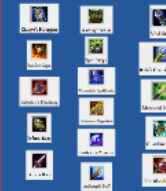
## Items

We used 33 of the most common items in this project.

Items can provide all manner of useful bonuses such as the 6 used

in this project:

Health  
Mana  
Attack Damage  
Armor  
Magic Resist  
Ability Power

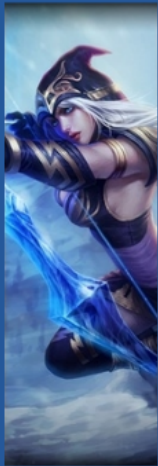


# *Champions*

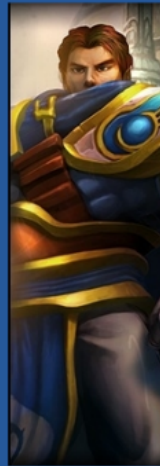
Champions Used in Project

We used 3 that are the best for beginning players

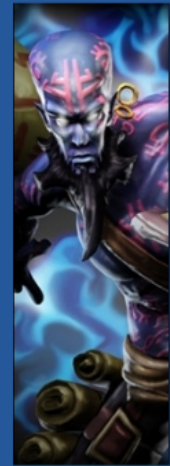
- Ashe



- Garen



- Ryze



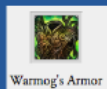
# Items

We used 33 of the most common items in this project. Items can provide all manner of useful bonuses such as the 6 used

in this project:  
Health  
Mana  
Attack Damage  
Armor  
Magic Resist  
Ability Power



Zhonya's Hourglass



Warmog's Armor



Void Staff



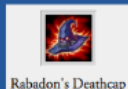
Sunfire Cape



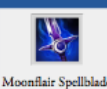
Spirit Visage



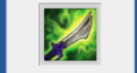
Rylai's Crystal Scepter



Rabadon's Deathcap



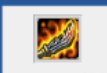
Moonflair Spellblade



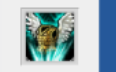
Mercurial Scimitar



Infinity Edge



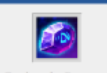
Guinsoo's Rageblade



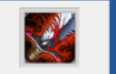
Guardian Angel



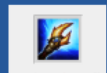
Doran's Blade



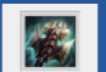
Catalyst the Protector



The Bloodthirster



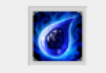
Archangel's Staff



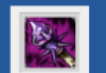
Titanic Hydra



Wit's End



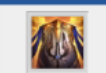
Tear of the Goddess



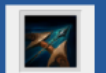
Rod of Ages



Sterak's Gage



Randuin's Omen



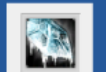
Last Whisper



Phage



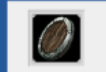
Kindlegem



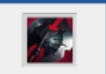
Frozen Heart



Hextech Gunblade



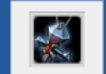
Doran's Shield



The Black Cleaver



Dead Man's Plate



Banshee's Veil



Abyssal Scepter

# Data and Optimization Problem

	Abyssal Scepter	Archangel's Staff	Banshee's Veil	Black Cleaver	Bloodthirster	Catalyst the Protector	Dead Man's Plate	Doran's Blade	Doran's Ring	Doran's Shield	Frozen Heart	Guardian Angel	Guinsoo's Rageblade	Hextech Gunblade	Infinity Edge	Kindlegem	Last Whisper	Mercurial Scimitar	Moonflair Spellblade	Phage	Rabadon's Deathcap	Randuin's Omen	Rod of Ages	Rylai's Crystal Scepter	Spirit Visage	Sterak's Gage	Sunfire Cape	Tear of the Goddess	Titanic Hydra	Void Staff	Warmogs Armor	Wit's End	Zhonya's Hourglass
Health	0	0	500	300	0	225	600	80	60	80	0	0	0	0	200	0	0	0	200	0	450	300	400	500	500	500	0	450	0	850	0	0	
Mana	0	250	0	0	0	300	0	0	0	0	400	0	0	0	0	0	0	0	0	0	0	400	0	0	0	0	250	0	0	0	0	0	
Attack Damage	0	0	0	55	75	0	0	8	0	0	0	0	30	40	65	0	25	75	0	15	0	0	0	0	0	0	0	50	0	0	0	0	0
Armor	0	0	0	0	0	0	50	0	0	0	90	60	0	0	0	0	0	0	50	0	0	60	0	0	0	45	0	0	0	0	0	0	45
Magic Resist	50	0	70	0	0	0	0	0	0	0	0	60	0	0	0	0	0	35	50	0	0	0	0	70	0	0	0	0	0	0	40	0	0
Ability Power	70	80	0	0	0	0	0	0	15	0	0	0	40	80	0	0	0	0	50	0	120	0	80	100	0	0	0	0	0	80	0	0	100
Total items	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Cost	2350	3100	2900	3500	3700	1200	2800	450	400	450	2800	2900	2800	3400	3600	800	1300	3700	2500	1250	3800	3000	3000	3200	2800	2700	2700	750	3600	2650	2850	2800	3500

Visiting mobafire.com, a strategy guide tool for LoL, provided stats of the most popular "builds" for the 3 champions. The popular "builds" are seen to be the optimum build for each champion.

The problem we are trying to solve is to minimize the cost of the champions build subject to at least the same stats as the recommended builds from the site.

Then compare our builds to the site builds validating to optimum build or improving the build.



# *Inputs*

The function takes inputs  $f$ ,  $A$ ,  $b$

```
champ = 'Ashe';
```

```
b = [800;0;220;60;130;0;6];
```

```
champ = 'Garen';
```

```
b = [2800;0;105;110;70;0;6];
```

```
champ = 'Ryze';
```

```
b = [1200;1050;0;90;70;380;6];
```

$f$  is the cost of gold for each item which is final row of the data shown in the previous slide.

$A$  is the remainder of the data which is stats of each item.

# Outputs

The outputs from our functions for all three characters.

## Ashe

With stacking items  
'1' 'Guardian Angel'  
'2' 'Mercurial Scimitar'  
'2' 'Phage'  
'1' 'Titanic Hydra'

Total cost is 16400 gold.

Without stacking items  
'Black Cleaver'  
'Guardian Angel'  
'Infinity Edge'  
'Last Whisper'  
'Mercurial Scimitar'  
'Spirit Visage'

Total cost is 17800 gold.

## Garen

With stacking items  
'1' 'Black Cleaver'  
'1' 'Dead Man's Plate'  
'1' 'Spirit Visage'  
'2' 'Sunfire Cape'  
'1' 'Titanic Hydra'

Total cost is 18100 gold.

Without stacking items  
'Black Cleaver'  
'Dead Man's Plate'  
'Randuin's Omen'  
'Spirit Visage'  
'Sunfire Cape'  
'Titanic Hydra'

Total cost is 18400 gold.

## Ryze

With stacking items  
'2' 'Moonflair Spellblade'  
'4' 'Rod of Ages'

Total cost is 17000 gold.

Without stacking items  
'Archangel's Staff'  
'Frozen Heart'  
'Rabadon's Deathcap'  
'Rod of Ages'  
'Rylai's Crystal Scepter'  
'Spirit Visage'

Total cost is 18700 gold.

## Ashe

With stacking items

- '1' 'Guardian Angel'
- '2' 'Mercurial Scimitar'
- '2' 'Phage'
- '1' 'Titanic Hydra'

Total cost is 16400 gold.

Without stacking items

- 'Black Cleaver'
- 'Guardian Angel'
- 'Infinity Edge'
- 'Last Whispher'
- 'Mercurial Scimitar'
- 'Spirit Visage'

Total cost is 17800 gold.

Total cost

## *Garen*

With stacking items

- '1' 'Black Cleaver'
- '1' 'Dead Man's Plate'
- '1' 'Spirit Visage'
- '2' 'Sunfire Cape'
- '1' 'Titanic Hydra'

Total cost is 18100 gold.

Without stacking items

- 'Black Cleaver'
- 'Dead Man's Plate'
- 'Randuin's Omen'
- 'Spirit Visage'
- 'Sunfire Cape'
- 'Titanic Hydra'

Total cost is 18400 gold.

ld.

## *Ryze*

With stacking items

- '2' 'Moonflair Spellblade'
- '4' 'Rod of Ages'

Total cost is 17000 gold.

Without stacking items

- 'Archangel's Staff'
- 'Frozen Heart'
- 'Rabadon's Deathcap'
- 'Rod of Ages'
- 'Rylai's Crystal Scepter'
- 'Spirit Visage'

Total cost is 18700 gold.

# Results

## MOBAfire.com Suggestions

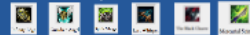


Health: 800  
Mana: 0  
Attack Damage: 220  
Armor: 60  
Magic Resist: 130  
Ability Power: 0

Total cost is 17900 gold.

## Ashe

## Matlab Optimization Result

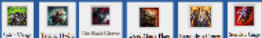


Health: 800  
Mana: 0  
Attack Damage: 220  
Armor: 60  
Magic Resist: 165  
Ability Power: 0

Total cost is 17800 gold.

## Garen

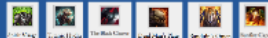
## MOBAfire.com Suggestions



Health: 2800  
Mana: 0  
Attack Damage: 105  
Armor: 110  
Magic Resist: 70  
Ability Power: 0

Total cost is 18400 gold.

## Matlab Optimization Result



Health: 2800  
Mana: 0  
Attack Damage: 105  
Armor: 155  
Magic Resist: 70  
Ability Power: 0

Total cost is 18400 gold.

## Ryze

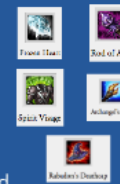
## MOBAfire.com Suggestions



Health: 1200  
Mana: 1050  
Attack Damage: 0  
Armor: 90  
Magic Resist: 70  
Ability Power: 380

Total cost is 18700 gold.

## Matlab Optimization Result



Health: 1200  
Mana: 1050  
Attack Damage: 0  
Armor: 90  
Magic Resist: 70  
Ability Power: 380

Total cost is 18700 gold.

# Results

## MOBAfire.com Suggestions



Health: 800

Mana: 0

Attack Damage: 220

Armor: 60

Magic Resist: 130

Ability Power: 0

Total cost is 17900 gold.

## Ashe

## Matlab Optimization Result



Health: 800

Mana: 0

Attack Damage: 220

Armor: 60

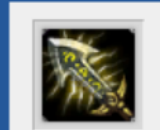
Magic Resist: 165

Ability Power: 0

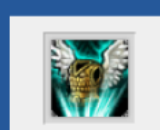
Total cost is 17800 gold.

# Ashe

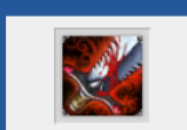
## MOBAfire.com Suggestions



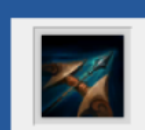
Infinity Edge



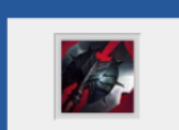
Guardian Angel



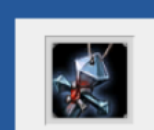
The Bloodthirster



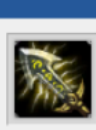
Last Whisper



The Black Cleaver



Banshee's Veil



Infinity Ed

Health: 800

Mana: 0

Attack Damage: 220

Armor: 60

Magic Resist: 130

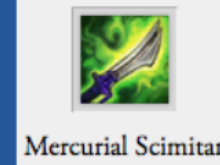
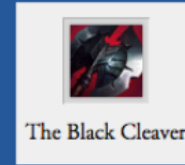
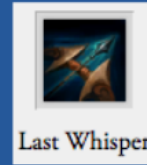
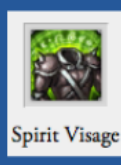
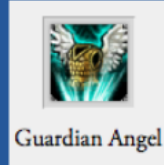
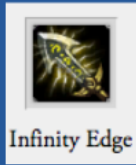
Ability Power: 0

Total cost is 17900 gold.



# Ashe

## Matlab Optimization Result



Health: 800

Mana: 0

Attack Damage: 220

Armor: 60

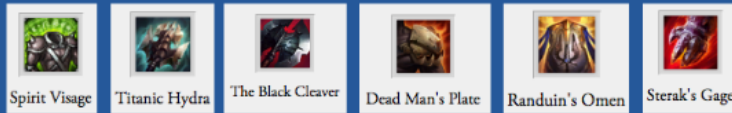
Magic Resist: 165

Ability Power: 0

Total cost is 17800 gold.

# Garen

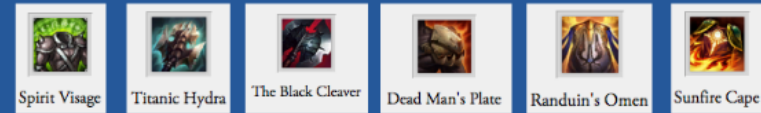
## MOBAfire.com Suggestions



Health: 2800  
Mana: 0  
Attack Damage: 105  
Armor: 110  
Magic Resist: 70  
Ability Power: 0

Total cost is 18400 gold.

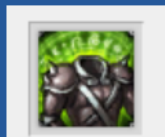
## Matlab Optimization Result



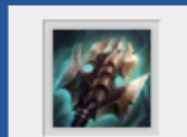
Health: 2800  
Mana: 0  
Attack Damage: 105  
Armor: 155  
Magic Resist: 70  
Ability Power: 0

Total cost is 18400 gold.

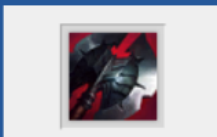
## MOBAfire.com Suggestions



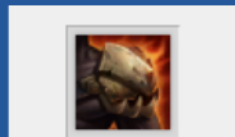
Spirit Visage



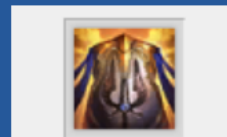
Titanic Hydra



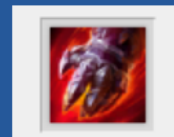
The Black Cleaver



Dead Man's Plate



Randuin's Omen



Sterak's Gage

Health: 2800

Mana: 0

Attack Damage: 105

Armor: 110

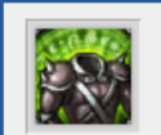
Magic Resist: 70

Ability Power: 0

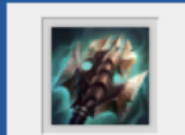
Total cost is 18400 gold.

# Garen

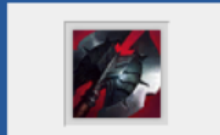
## Matlab Optimization Result



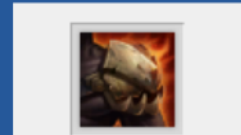
Spirit Visage



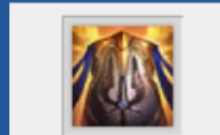
Titanic Hydra



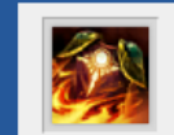
The Black Cleaver



Dead Man's Plate



Randuin's Omen



Sunfire Cape

Health: 2800

Mana: 0

Attack Damage: 105

Armor: 155

Magic Resist: 70

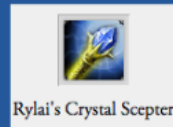
Ability Power: 0

Total cost is 18400 gold.

300 gold.

## Ryze

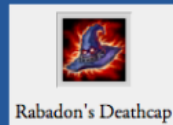
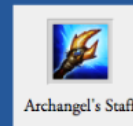
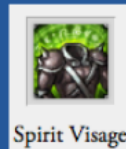
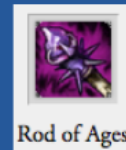
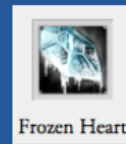
MOBAfire.com Suggestions



Matlab Optimization Result

Health: 1200  
Mana: 1050  
Attack Damage: 0  
Armor: 90  
Magic Resist: 70  
Ability Power: 380

Total cost is 18700 gold.




Health: 1200  
Mana: 1050  
Attack Damage: 0  
Armor: 90  
Magic Resist: 70  
Ability Power: 380

Total cost is 18700 gold.

# Linear Programming for MOBA Strategy Video Games


**The Video Game**

- Multiplayer Online Battle Arena (MOBA)
- League of Legends (LoL)
- Champions and Items



**Linear Programming**

- Built-In MATLAB *linprog* and *intlinprog*
- Simplex Method function *lpsimplex.m*
- Other Methods?



**Data and Optimization Problem**

Champion	Item	Cost	Health	Mana	Attack	Defense	Speed
Axe	Blade of the Ruined King	3000	100	0	10	10	10
	Winged Cuirass	1000	0	0	0	0	0
	Winged Cuirass	1000	0	0	0	0	0
Yasuo	Blade of the Ruined King	3000	100	0	10	10	10
	Winged Cuirass	1000	0	0	0	0	0
	Winged Cuirass	1000	0	0	0	0	0
Yasuo	Blade of the Ruined King	3000	100	0	10	10	10
	Winged Cuirass	1000	0	0	0	0	0
	Winged Cuirass	1000	0	0	0	0	0


The optimization problem is to maximize the total health, mana, attack, and defense of the champion, subject to the constraint that the total cost of the items does not exceed the available gold.

**Results**



**Outputs**

The outputs from our functions for all three champions.



**Inputs**

The function calls require 4 A, b, c, and x0.

champion = 'Axe';  
b = [1000 1000 1000 1000 1000 1000 1000 1000];  
c = [1000 1000 1000 1000 1000 1000 1000 1000];  
champion = 'Yasuo';  
b = [1000 1000 1000 1000 1000 1000 1000 1000];  
c = [1000 1000 1000 1000 1000 1000 1000 1000];

The cost of gold for each item which is returned the data shown in the previous slide.

A is the remainder of the data which is costs of each item.