Application of Greedy Algorithm to Find the Best Weapons in Apex Legends

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***Abstract*—Apex Legends is a First Person Shooter (FPS) game where you and your team fight other teams with weapons and abilities from characters you choose called Legends. There are modes to play in Apex Legends, for example Trios, Duos and Arenas. This paper will discuss the best weapon to use by using Greedy Algorithm, with some limitation.**

Keywords—Apex Legends, Weapon, Greedy, Algorithm

I. Introduction

Video games are electronic games which uses user interface, for example controller or keyboard, to generate feedback. Video games have become a big part of many people lives. There are a lot of games companies that have popped up, from big ones to indies ones. Video games are mostly used for entertainment. Some people play games as a job, making videos about it or participate in a game competition with big reward. Some people just want to play to elevate stress. Video games are also a great way to tell a story, like a movie or a comic. A type of game where you shoot with your weapon is called a First Person Shooter (FPS)

Figure 1.1. Cover Art of Current Season of Apex Legends (Source:https://store.steampowered.com/app/1172470/Apex_Legends/)

Apex Legends is a First Person Shooter (FPS) game developed by Respawn Entertainment and published by Electronic Arts. It was released for Microsoft Windows, PlayStation 4, and Xbox One in February 2019, for Nintendo Switch in March 2021, and for PlayStation 5, Xbox Series X/S in March 2022. Apex Legends supports cross platforms meaning people that plays on other platforms can still play together. A mobile version of Apex Legends for Android and OS was released on May 17, 2022, but this version has different mechanics, damage from weapons, and other things from the original game. This version also does not support cross platforms.

Apex Legends have some main modes, for example Trios, Duos, and Arenas. Sometimes Apex Legends have limited time modes, like Control and Flashpoint. Trios is a battle royale mode, where you play as a team of three and drop to a location in a big map. You have to find recourses and fight other teams to win. Duos is the same as Trios, but in groups of two. Arenas is a mode where you and your team, in a group of three, fight another group of three over multiple rounds. But, instead of finding resources, you have currencies to buy those recourses, like weapons and healing items. The objective of this mode is to eliminate all members of the opposing team for each round.

The focus of this paper is to use Greedy Algorithm to find the best weapon to use. This means comparing each weapon. Because Apex Legends is a skill-based game, Finding the best weapon need some limitation. This paper does not focus on the abilities from the characters called Legends that you can use. This paper also does not focus on items like grenades and healing items.

II. Theoretical Basis

A. *Greedy Algorithm*

Greedy algorithm is the most popular algorithm and very simple to solve problems based on optimization. This algorithm solves the problem sequentially step by step without going back to the previous step. It works in a top-down approach. This algorithm may not produce the best result for all problem. it's because it always goes for the local best choice to produce global best choice. You can tell by the name "greedy"; this algorithm is greedy because it always chooses the best choice for each step without caring about the nest steps of choosing [1].

Greedy Algorithm has its plus and minus. The positive thing about greedy algorithm is that this algorithm is fast and simple in comparison to other algorithms. The bad thing about it is that it doesn't always produce the best optimal solution, instead it produces solutions near the optimal solution (pseudo-optimum). But instead of finding the best optimal solution but

using a lot of time to find that solution, we can accept a pseudo-optimal solution. Optimisation only have two things, maximisation or minimisation [2][3].

Greedy algorithms have elements, and they are:

- Candidate sets (C),

  is a set that will be chosen from for each step.

- Solution sets (S)

  is a set of candidates that have been chosen. This set is a subset of candidate sets.

- Solution function

  is a function that will determine if a candidate set have given a solution.

- Selection function

  is a function that choses a candidate from the candidate sets that implements some kind of greedy strategy that is heuristic.

- Feasible function

  is a function that checks is a candidate that has been chosen can be included in the solution set without violating the limitations that have been defined.

- Objective function

  is a function that is tied to the optimisation that wants to be optimised, whether the choices is maximised or minimised.

Greedy algorithm is often used as an alternative for optimisation problem that needs a quick solution. Some problems that can be solved with the greedy algorithm is the knapsack problem, choosing activities, the shortest distance, money change problem, and so on.

B. Knapsack Problem

The Knapsack problem is an optimization problem which goal is to maximize profits. Suppose there is a set of objects, each of which has heaviness (weight) and value (profit). These objects must be placed in a storage medium so that the largest total value is obtained without exceeding the capacity of the storage medium itself. There are two types of knapsack problem, integer knapsack problem or 1/0 knapsack problem and fractional knapsack problem.

The knapsack problem can be solved by greedy algorithm. By utilizing a certain greedy heuristic strategy, objects are entered one by one without removing previously entered object. Heuristic strategy which can be used are as follows. Note that none of the strategies below guaranties the most optimal solution.

- Greedy by profit

  is the strategy of trying to maximize profit by selecting objects with the largest value first. If there are values that are the same, then the smallest weight is prioritized first.

- Greedy by weight

  is the strategy of trying to maximize profit by selecting objects with the lightest weight first, which means this strategy will include as many objects as possible so that the optimal solution is expected. If there are objects with the same weight, then the biggest value is prioritized first.

- Greedy by density

  is a strategy that tries maximizing profit by selecting objects with the greatest density first, in this case density is the ratio between the value and the weight of an object. If there are objects with the same density, then the biggest value is prioritized first.

C. Apex Legends

Apex Legends is a First Person Shooter (FPS) game developed by Respawn Entertainment and published by Electronic Arts [4]. It was released for Microsoft Windows, PlayStation 4, and Xbox One in February 2019, for Nintendo Switch in March 2021, and for PlayStation 5, Xbox Series X/S in March 2022. Apex Legends supports cross platforms meaning people that plays on other platforms can still play together. A mobile version of Apex Legends for Android and OS was released on May 17, 2022, but this version has different mechanics, damage from weapons, and other things from the original game. This version also does not support cross platforms.

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Figure 2.1. Weapon List from Arenas Mode
(Source: https://www.ea.com/games/apex-legends/news/introducing-arenas

a) Types

There are types of weapons in Apex Legends. They are pistols, shotguns, LMGs (Light Machine Guns), SMGs (Sub Machine Guns), assault rifles, marksman, and sniper. Shotguns have higher damage because it shoots many bullets at once, but they spread out a lot so it's better for short range. Snipers have high damage, but the time between shots are high so it's better at long range. These weapon types cater a lot of players play styles.

b) Damage

Weapons also have different damage. Pistols have lower damage than a sniper. Shotguns have higher damage than an assault rifle. The damage is also different from where you shoot at. You can shoot at the head, body, or legs. Damage on the head is higher damage than damage on the body, and damage on the body is higher than damage on the legs. For this, we can only focus on the body part.

c) Attachments

Weapons have different attachments they can use. For example, a HAVOC Rifle.

Figure 2.2. HAVOC Rifle Attachments
(Source: Apex Legends, 2022, Electronic Arts)

On a HAVOC Rifle, you can have an energy magazine which increase the magazine size (increase the amount of bullets between rounds), an optic to scope other players, a standard stock to reduce aim drift and reload time, also increase handling, and a hop-up. There are many hop-ups in Apex Legends, but in HAVOC, you can only use Tubocharger, which reduce the wind-up time. There are no attachements that increase damage.

d) Time

There are many different time variables, like reload time, time between shots, and different time variable exclusive for certain weapons. For example, a HAVOC Rifle.

HAVOC Rifle have a wind-up time before shooting. Wind-up time is only exclusive to HAVOC Rifle and Devotion.

Below is a table of the weapons you can use

Table 1. Weapons in Apex Legends

Weapon	Type	DPS	Damage
Mastiff Shotgun	Shotgun	134	112 14×8
Triple Take	Marksman weapon	76	63 21×3
Mozambique Shotgun	Shotgun	99	45 15×3
Peacekeeper	Shotgun	90	99 9×11
Charge Rifle	Sniper rifle	39	90 3×15+45
EVA-8 Auto	Shotgun	108	54 6×9
Kraber .50-Cal Sniper	Sniper rifle	58	140
Sentinel	Sniper rifle	36 46	70 88
Longbow DMR	Sniper rifle	72	55
Wingman	Pistol	117	45
30-30 Repeater	Marksman weapon	97	42-57
G7 Scout	Marksman weapon	144	36
Rampage LMG	LMG	130 169	26

 Bocek Compound Bow	Marksman weapon	75-107	25-60
 Hemlok Burst AR	Assault rifle	128	20
 HAVOC Rifle	Assault rifle	202	18
 M600 Spitfire	LMG	162	18
 P2020	Pistol	126	18
 VK-47 Flatline	Assault rifle	180	18
 L-STAR EMG	LMG	170	17
 Volt SMG	SMG	204	17
 Alternator SMG	SMG	160	16
 Devotion LMG	LMG	75-225	15
 Prowler Burst PDW	SMG	163	14
 R-301 Carbine	Assault rifle	189	14
 C.A.R. SMG	SMG	202	13
 RE-45 Auto	Pistol	156	12
 R-99 SMG	SMG	198	11

Other than weapon, there are also helmets and evo shields. every player starts with a level 1 evo shields and helmets. Evo shields protect player from 50 damage with every player have 100 health, so there need to be 150 damage to eliminate other player. Helmets reduce headshot damage.

III. Application of Greedy Algorithm

The problem to be solved is the maximation of damage to another player. This is an example of a knapsack problem. This problem can be solved with greedy algorithms.

- The knapsack capacity is the time. For this, we can use 5 seconds.
- Candidate sets (C),

  The candidate sets are one shot of bullet from each weapon
- Solution sets (S)

  The solution sets are the shots that have been shot.
- Solution function

  The solution function is checking if the total amount of time from the shots that have been shot is near 5 seconds
- Selection function

  Selection function in this problem is heuristic greedy algorithm.
- Feasible function

  Feasible function in this problem is if the shot is to be taken, the total time is still lower than 5 seconds. Also, the shot can only be from 2 different weapons, because players can only carry 2 weapons.
- Objective function

  The objective function is the maximisation of damage that have been shot.

Before the algorithm, we need to determine the weight and profit. The weight is the time for each shot. In table 1, we can see the DPS or Damage Per Seconds. This is the average of damage from each weapon if it is shot to the body for each second. From this, we can divide damage from each shot by the DPS to get the average time for each shot. For the profit, we use the damage for each shot from every weapon. If the damage is in a range, we can get the average of it. There are also certain ammos for each magazine for each weapon. For each amount of ammo, there are that many object with the same weight and profit. Below is the table for those information.

Table 2. Information for Greedy Algorithm

No.	Weapon	w	p	p/w	Ammo
1	Mastiff Shotgun	0,835821	112	134	4
2	Triple Take	0,828947	63	76,00003	18
3	Mozambique shotgun	0,454545	45	99,0001	6
4	Peacekeeper	1,1	99	90	5
5	Charge Rifle	2,307692	90	39,00001	8
6	Eva-8 Auto	0,5	54	108	8
7	Kraber .50-cal Sniper	2,413793	140	58	4
8	Sentinel	1,944444	70	36,00001	4

9	Charged Sentinel	1,913043	88	46,00001	4
10	Longbow DMR	0,763889	55	71,99999	6
11	Wingman	0,384615	45	117,0001	6
12	30-30 Repeater	0,510309	49,5	97,00005	6
13	G7 Scout	0,25	36	144	20
14	Rampage LMG	0,2	26	130	28
15	Charged Rampage LMG	0,376812	26	68,99993	28
16	Bocek Compound Bow	0,467033	42,5	90,99999	∞
17	Hemlok Burst AR	0,15625	20	128	18
18	HAVOC Rifle	0,089109	18	201,9998	24
19	M600 Spitfire	0,111111	18	162,0002	35
20	P2020	0,142857	18	126,0001	14
21	VK-47 Flatline	0,1	18	180	20
22	L-STAR EMG	0,1	17	170	∞
23	Volt SMG	0,083333	17	204,0008	28
24	Alternator SMG	0,1	16	160	19
25	Devotion LMG	0,1	15	150	36
26	Prowler Burst PDW	0,08589	14	162,9992	20
27	R-301 Carbine	0,074074	14	189,0002	18
28	C.A.R. SMG	0,064356	13	202,0014	20
29	RE-45 Auto	0,076923	12	156,0002	16
30	R-99 SMG	0,055556	11	197,9984	20

A. *Greedy by Weight*

For Greedy by weight, we need to use the smallest weight. The smallest is R-99 SMG with 0,055556 seconds. We can take all 20 ammos, and that leaves us 3,88888 seconds left and get 220 damage. The next smallest one is C.A.R. SMG, with 0,076923 seconds. We can take all 20 ammos and that leaves us with 2,35042 seconds left and get 260 damage. But because we can only take 2 weapons, that's the end of the algorithm. So, for Greedy by weight, the algorithm use all the ammos from R-99 SMG and C.A.R. SMG and use 2,64958 seconds of weights with a profit of 480 damage.

B. *Greedy by Profit*

For Greedy by profit, we need to use the biggest profit. The biggest one is Kraber .50-cal Sniper with a profit of 140 damage. But the algorithm can only use 2 ammos because the weight will be over 5 second. So, we use 2 ammos and that leaves us with 0,172414 seconds and get 280 damage. The other biggest one that can be used is Hemlok Burst AR and the algorithm can only use 1 ammo to not overflow the weight and that leaves us with 0,016164 seconds and get 20 damage. We cannot take any more weapons. So, for greedy by profit, the algorithm uses 2 ammos of Kraber .50-cal Sniper and 1 ammo of Hemlok Burst AR and use 4,983836 seconds of weights with a profit of 300 damage.

C. *Greedy by Density*

For Greedy by density, we need to use the biggest density. the biggest density is from Volt with 204,0008. The algorithm can use all 28 ammos and that leaves us with 2,666676 seconds and get 476 damage. The other biggest one is C.A.R. SMG with 202,0014. The algorithm can use all 20 ammo and leaves us with 1,379556 seconds and get 260 damage. The algorithm cannot take another weapon. So, for greedy by density, we can we use all ammos from VoltSMG and C.A.R. SMG and use 3,620444 seconds of weights with a profit of 736 damage.

IV. Conclusion

Greedy algorithm is a great method in solving optimization problems like knapsack problem. In this paper, that problem is finding the best weapons to inflict damage before a set amount of time. Even though Greedy algorithm does not always produce the most optimal solution, it is fast to compute and produces solutions near the optimal solution (pseudo-optimum). By looking at the results of the greedy algorithm, Greedy by Density produces the biggest profit with 736 damage. This is not necessarily the most optimal solution, so other algorithm is needed to reassure this result.

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PERNYATAAN

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