Using Greedy Algorithm to Determine the Most Profits Obtainable in the Game Stardew Valley

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***Abstract*—In the game Stardew Valley, farming is one of the main methods for players to earn money. This paper finds out how the player can get the most profits for each season in the game, 28 days each. Doing so will also determine the most profitable crops for each season. As the seeds the player are able to obtain vary in time spent in-game, this paper will also explore the profits of realistic crops a player can get through a gameplay. The search of the most profitable crops to plant will be calculated using the greedy algorithm.**

Keywords—crops; profits; days; greedy algorithm

I. Introduction (*Heading 1*)

Stardew Valley is an country-life RPG video game. It is an indie game developed by Eric "ConcernedApe" Barone and published by Chucklefish. The game was first launched on Steam GreenLight in September 2012 and finally released on Steam in February 2016 [1][2].

In Stardew Valley, the player takes control of a character who is sick of the city life and decides to take over their late grandfather's untended farm in the place called Stardew Valley. The players tend the farm while also being able to interact with the residents of the town. To earn money, the player is able to do various things such as farming, mining, and fishing.

Figure 1. Stardew Valley Title Screen

Farming in Stardew Valley is done by planting seeds on tilled land in the player's farm. The crops that will grow will differ on each season. Crops require several days to grow until harvest. Each season last for 28 days. When the season change, any crops not compatible for the season will instantly die.

As the price for each seed and the sell price of each crops varies. To get the most profits, choosing the crops that will bear the most profits and are able to be planted with the limited time for each season is one problem a player will face.

II. Greedy Algorithms

The *greedy algorithm* is an algorithm which always makes the choice that looks most optimal at the moment. It makes a locally optimal choice, hoping that it will lead to a globally optimal solution [3]. The algorithm will continue to select a locally optimal choice until the end. The greedy algorithm does not always result in an optimal solution, but it does for some problems.

A greedy algorithm has five elements:

1. a candidate set, the set that contains all possible choices from which a choice is made to create the solution,
2. a selection function, the function which chooses the best candidate to be added to the solution
3. a feasibility function, the function used to determine whether a candidate can be added to the solution
4. an objective function, the function which assigns a value to a solution or partial solution, and
5. a solution function, which indicates when a complete solution is found.

For a greedy algorithm to solve a particular optimization problem, the problem which the algorithm is applied to needs to have two ingredients:

1. Greedy-choice property

   The choice made by a greedy algorithm can depend on choices so far, but it cannot depend on future choices or on the solutions to subproblems.

2. Optimal substructure

   A problem has optimal substructure if an optimal solution to the problem contains optimal solutions to subproblems.

III. Crops in Stardew Valley

There are several crops in Stardew Valley. Some crops can only be obtained on special occasions or after certain in-game years. There are 4 seasons in the game which are spring, summer, fall, and winter. Winter does not have any growable crops.

There are generally 2 types of crops, crops that are harvestable once and crops with multiple harvests. Some crops also yields more than 1 per harvest.

Below is the list of all crops for each seasons, including the seed price, base sell price, and growth time. Seed prices are obtained from the price in the stores, sell price obtained from gold earned after selling, and growth time available on the seeds' description in-game.

A. Spring Crops

These are the crops only growable in spring.

1) Single Harvest Crops

Table 1. Spring Single Harvest Crops

Name	Seed Price	Base Sell Price	Growth Time	Average amount per harvest
Blue Jazz	30g	50g	7 days	1
Cauliflower	80g	175g	12 days	1
Garlic	40g	60g	4 days	1
Kale	70g	110g	6 days	1
Parsnip	20g	35g	4 days	1
Potato	50g	80g	6 days	1.2
Rhubarb	100g	220g	13 days	1
Tulip	20g	30g	6 days	1

2) Multiple Harvests Crops

Table 2. Spring Multiple Harvests Crops

Name	Seed Price	Base Sell Price	Growth Time	Regrowth Time	Average amount per harvest
Green Bean	60g	40g	10 days	3 days	1
Strawberry	100g	120g	8 days	4 days	1

B. Summer Crops

These are the crops only growable in summer.

1) Single Harvest Crops

Table 3. Summer Single Harvest Crops

Name	Seed Price	Base Sell Price	Growth Time	Average amount per harvest
Melon	80g	250g	12 days	1
Poppy	100g	140g	7 days	1
Radish	40g	90g	6 days	1
Red Cabbage	100g	260g	9 days	1
Starfruit	400g	750g	13 days	1
Summer Spangle	50g	90g	8 days	1
Sunflower	200g	80g	8 days	1
Wheat	10g	25g	4 days	1

2) Multiple Harvests Crops

Table 4. Summer Multiple Harvests Crops

Name	Seed Price	Base Sell Price	Growth Time	Regrowth Time	Average amount per harvest
Blueberry	80g	50g	13 days	4 days	3
Hops	60g	25g	11 days	1 day	1
Hot Pepper	40g	40g	5 days	3 days	1
Tomato	50g	60g	11 days	4 days	1

C. Fall Crops

These are the crops only growable in fall.

1) Single Harvest Crops

Table 5. Fall Single Harvest Crops

Name	Seed Price	Base Sell Price	Growth Time	Average amount per harvest
Amaranth	70g	150g	7 days	1
Artichoke	30g	160g	8 days	1
Beet	20g	100g	6 days	1
Bok Choy	50g	80g	4 days	1
Fairy Rose	200g	290g	12 days	1

Pumpkin	100g	320g	13 days	1
Sweet Gem Berry	1000g	3000g	24 days	1
Yam	60g	160g	10 days	1

2) Multiple Harvests Crops

Table 6. Fall Multiple Harvests Crops

Name	Seed Price	Base Sell Price	Growth Time	Regrowth Time	Average amount per harvest
Cranberries	240g	75g	7 days	5 days	2
Eggplant	20g	60g	5 days	5 days	1
Grape	60g	80g	10 days	3 days	1

D. Multi-Season Crops

These are the crops that can be grown in multiple seasons.

Table 7. Multi-Season Crops

Name	Seasons
Ancient Fruit	Spring, Summer, Fall
Coffee Bean	Spring, Summer
Corn	Summer, Fall

1) Multiple Harvests Crops

Table 8. Multi-Season Multiple Harvests Crops

Name	Seed Price	Base Sell Price	Growth Time	Regrowth Time	Average amount per harvest
Ancient Fruit	-	550g	28 days	7 days	1
Coffee Bean	2500 g	15g	10 days	2 days	4
Corn	150g	50g	14 days	4 days	1

Figure 2. A field of cranberries planted in groups of 9x9 tiles.

E. Special Crops

Some crops are not obtainable by normal means from the store, or is not available until some point of the game. These seed are typically not available or easily obtained for the player at the first year.

Table 9. Special Crops

Name	Source	Time Available
Coffee Bean	The Travelling Cart, Monster Loot Drop	Anytime
Garlic	Store	From Year 2
Rhubarb	Oasis Store	When the desert is unlocked
Strawberry	Festival Shop	At the Egg Festival (13th Spring)
Red Cabbage	Store	From Year 2
Starfruit	Oasis Store	When the desert is unlocked
Artichoke	Store	From Year 2
Beet	Oasis Store	When the desert is unlocked
Sweet Gem Berry	Travelling Cart	Anytime
Ancient Fruit	Random Artifact Drop	Anytime

IV. Scope of Problem

This paper will only find out the most profits the player can get from each season. This paper will not calculate cross-season crops which the player has planted in the season before.

This paper will assume all seeds was obtained by purchasing the seed.

This paper will not account the crop growth modifiers in the game.

V. Most Profits in One Season

This part will discuss the most profitable crops for each season. This will help players decide which crops to plant to get the most money.

The most profits that will be calculated is how much money the player can get from a single tile in a season. This means planting the most plants with the most profits in the limited time (28 days).

This Problem can be simplified into an improvised version of the knapsack problem, in which every item can be picked more than once. The algorithm picks crops to plant until there is not enough days to plant any crops.

The profit (p) of an item can be described as the sell price times the average amount per harvest, minus the seed price. The weight (w) of each crop and be described as the amount of days required to grow the crops.

Regrowable crops harvests can be grouped as the total amount of harvests in a season, with the profits as the total profits of all harvests, and the weight as the total amount of days for that many harvests. The amount of harvests will be marked as [N]. These items can only be picked once.

Because crops will only the start growing the day after planting, the knapsack capacity (K) will be the amount of days in one season minus 1. K = 27.

For each season, this paper will find out the most profits when the player is still in year 1 (no special crops), and on other years (with special crops).

These are the elements of this greedy algorithm in this problem:

1. Candidate set: the set of all possible crop combinations that can be planted consecutively in one season
2. Selection function: chooses the crop with the highest profit per day.
3. Feasibility function: the solution can only choose the crop which weight (days) is less than the remaining days.
4. Objective function: the solution grant the player the most gold for each tile in one season.
5. Solution function, there exist no more crops that can be planted in the remaining days.

A. *Spring*

1) First Year (No Special Crops)

These are the crops that can be chosen. Because strawberry seeds can only be bought at 13th Spring, the maximum harvest for the first year will only be 2.

i	Crop	*p* (gold)	*w* (days)	*p/w*
1	Blue Jazz	20	7	2.86
2	Cauliflower	95	12	7.92
3	Kale	40	6	6.67
4	Parsnip	15	4	3.75
5	Potato	46	6	7.67
6	Tulip	10	6	1.67
7	Green Bean [6]	180	25	7.2
8	Strawberry [2]	140	12	11.67

i	Greedy by		
	profit	*weight*	*density*
1	0	0	0
2	0	0	1
3	0	0	0
4	0	6	0
5	0	0	0
6	0	0	0
7	1	0	0
8	0	0	1
Total weight	25	24	24
Total profit	180	90	235

Greedy by density will result the most optimal solution X = (0, 1, 0, 0, 0, 0, 0, 1). This means that the player can get the most money by planting cauliflowers followed by strawberries, with a total profit of 235g per tile.

2) Second Year Onwards (With Special Crops)

These are the crops that can be chosen.

i	Crop	*p* (gold)	*w* (days)	*p/w*
1	Blue Jazz	20	7	2.86
2	Cauliflower	95	12	7.92
3	Kale	40	6	6.67
4	Parsnip	15	4	3.75
5	Potato	46	6	7.67
6	Tulip	10	6	1.67
7	Green Bean [6]	180	25	7.2
8	Strawberry [5]	600	24	11.67
9	Garlic	20	4	5
10	Rhubarb	120	13	9.23
11	Coffee Bean [9]	-1960	26	-75.38

i	Greedy by		
	profit	*weight*	*density*
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	0	0
7	0	0	0
8	1	0	1
9	0	6	0
10	0	0	0
11	0	0	0
Total weight	24	24	24
Total profit	600	120	600

Greedy by density and by profit will result the most optimal solution X = (0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0). This means that the player can get the most profit by only planting strawberries throughout the season, with a total profit of 600g per tile.

B. Summer

1) First Year (No Special Crops)

These are the crops that can be chosen.

i	Crop	*p* (gold)	*w* (days)	*p/w*
1	Melon	170	12	14.17
2	Poppy	40	7	5.71
3	Radish	50	6	8.33
4	Summer Spangle	40	8	5
5	Sunflower	-120	8	-15
6	Wheat	15	4	3.75
7	Blueberry [4]	520	25	20.8
8	Hops [17]	365	27	13.52
9	Hot Pepper [8]	280	26	10.77
10	Tomato [5]	250	27	9.26
11	Corn [4]	50	26	1.92

i	Greedy by		
	profit	*weight*	*density*
1	0	0	0
2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	0
6	0	6	0
7	1	0	1
8	0	0	0
9	0	0	0
10	0	0	0
11	0	0	0
Total weight	25	24	25
Total profit	520	90	520

Greedy by profit and by density will result the most optimal solution X = (0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0). This means that the player can get the most money by planting only blueberries throughout the season, with a total profit of 520g per tile.

2) Second Year Onwards (With Special Crops)

These are the crops that can be chosen.

i	Crop	*p* (gold)	*w* (days)	*p/w*
1	Melon	170	12	14.17
2	Poppy	40	7	5.71
3	Radish	50	6	8.33
4	Red Cabbage	160	9	17.78
5	Starfruit	350	13	26.92
6	Summer Spangle	40	8	5
7	Sunflower	-120	8	-15
8	Wheat	15	4	3.75
9	Blueberry [4]	520	25	20.8
10	Hops [17]	365	27	13.52
11	Hot Pepper [8]	280	26	10.77
12	Tomato [5]	250	27	9.26
13	Coffee Bean [9]	-1960	26	-75.38
14	Corn [4]	50	26	1.92

i	Greedy by		
	profit	*weight*	*density*
1	0	0	0

2	0	0	0
3	0	0	0
4	0	0	0
5	0	0	2
6	0	0	0
7	0	0	0
8	0	6	0
9	1	0	0
10	0	0	0
11	0	0	0
12	0	0	0
13	0	0	0
14	0	0	0
Total weight	25	24	26
Total profit	520	90	700

Greedy by density will result the most optimal solution X = (0, 0, 0, 0, 2, 0, 0, 0, 0, 0, 0, 0, 0, 0). This means that the player can get the most money by planting starfruits twice during the season, with a total profit of 700g per tile.

C. Fall

1) First Year (No Special Crops)

These are the crops that can be chosen.

i	Crop	*p* (gold)	*w* (days)	*p/w*
1	Amaranth	80	7	11.43
2	Bok Choy	30	4	7.5
3	Fairy Rose	90	12	7.5
4	Pumpkin	220	13	16.92
5	Yam	100	10	10
6	Cranberries [5]	510	27	18.89
7	Eggplant [5]	280	25	11.2
8	Grape [6]	420	25	16.8
9	Corn [4]	50	26	1.92

i	Greedy by		
	profit	*weight*	*density*
1	0	0	0
2	0	6	0
3	0	0	0
4	0	0	0
5	0	0	0
6	1	6	1
7	0	0	0
8	0	0	0
9	0	0	0
Total weight	27	24	27
Total profit	510	180	510

Greedy by profit and by density will result the most optimal solution X = (0, 0, 0, 0, 0, 1, 0, 0, 0). This means that the player can get the most money by planting only cranberries throughout the season, with a total profit of 510g per tile.

2) Second Year Onwards (With Special Crops)

These are the crops that can be chosen.

i	Crop	*p* (gold)	*w* (days)	*p/w*
1	Amaranth	80	7	11.43
2	Artichoke	130	8	16.25
3	Beet	80	6	13.33
4	Bok Choy	30	4	7.5
5	Fairy Rose	90	12	7.5
6	Pumpkin	220	13	16.92
7	Sweet Gem Berry	2000	24	83.33
8	Yam	100	10	10
9	Cranberries [5]	510	27	18.89
10	Eggplant [5]	280	25	11.2
11	Grape [6]	420	25	16.8
12	Corn [4]	50	26	1.92

i	Greedy by		
	profit	*weight*	*density*
1	0	0	0
2	0	0	0
3	0	0	0
4	0	6	0
5	0	0	0
6	0	0	0
7	1	0	1
8	0	0	0

9	0	0	0
10	0	0	0
11	0	0	0
12	0	0	0
Total weight	24	24	24
Total profit	2000	180	2000

Greedy by density will result the most optimal solution X = (0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0). This means that the player can get the most money by planting sweet gem berries during the season, with a total profit of 2000g per tile

VI. Conclusion

The greedy algorithm can be applied to all sorts of things, one of those things being video games.

In Stardew Valley, using the greedy algorithm, it has been found the most profits a player can get in one season for each tile. Be it for using only easily obtainable seeds, or also special seeds. Using this, players will be able to acquire the most money in the limited time of each season.

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PERNYATAAN

Dengan ini saya menyatakan bahwa makalah yang saya tulis ini adalah tulisan saya sendiri, bukan saduran, atau terjemahan dari makalah orang lain, dan bukan plagiasi.

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