

Decision Tree Application to Find the Optimal Way of Spending Daily Life Activities in Persona 4

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Abstract— Video games has come a long way. What used to be a simple thing to have fun has now become a hobby to many people. Some games offer a lot of freedom to the players and give them different choices on what to do. Although it is a positive thing, this can cause some players to be confused on what to do and some will be unable to experience the game to its potential. To solve this, we can analyze the game mechanics and use discrete mathematics, in this case decision tree, in order to find the best course of action in this game.

Keywords—Tree, Graph, Decision, Persona

I. INTRODUCTION

Graph can be used in many applications. Consist of nodes and edges, graph is commonly used to represent discrete object relation with one another. One form of a graph is a tree. A tree is a connected graph that doesn't have any circuit inside it. Tree also has a wide range of use one example is for representing information and structures. A common type of tree is binary tree. This type of tree can only have a maximum of 2 branch. Another use of tree is to make a decision tree. A decision tree is a support tool that uses a tree model to help decision-making problems. A decision tree is not necessarily a binary since there make be more than two choices to decide. In this paper, we will be using decision tree to choose the best way to spend the daily life on a Japanese role-playing game Persona 4.

A Role-Playing Game (RPG) is a video game genre where the player has controls of the character in the game in a more immersive ways than another video game genre. This is because the player is able to develop the game character as they please, of course to some extent. This can be in how they play the game, how they choose certain narrative element, how they want their character to become, or some other choices. RPGs are also known for their replay value because of the choices and the different outcome of each choices that they have. A Japanese Role-Playing Game (JRPG) is a subgenre from RPG which is made in East Asia, most knowingly Japan. There is certain game aspect that distinguish JRPG from western RPG, most notably the art style and the gameplay. Most JRPG are a strategy/tactical turn-based game. The player will be given a turn to decide on what action needs to be taken. Other than that, JRPG uses party system rather than a single main character.

The game that will be covered here is Persona 4, a JRPG developed by Atlus, a Japanese video game company. Persona 4 is a unique JRPG. It uses a calendar system, which makes the game fairly linear and time limited. The player can spend the days on several activity which will be explained later. Because of this time limit and several choices, the player will need to spend their days carefully in the game. Hence, we apply the decision tree to find the activities that needs to be done to spend the days efficiently.

II. BASIC THEORIES

A. Graph

A graph, represented by $G = (V, E)$, is a tuple consists of V , a nonempty set of nodes or vertices, and E , a set of edges, and each edge connect to one or two vertices. A graph is used to represent a discrete object and its relation with another object. For example, a graph representing a computer network in which the vertices represent data centers and the edges represent communication links would look like this.

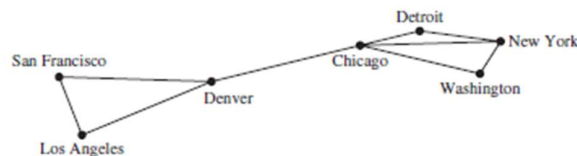


Image 2.1 Computer Network Graph

(Source: Discrete Mathematics and Its Applications 7th Ed, Kenneth Rosen)

In the Image above we have a set of vertices $V = \{\text{San Francisco, Los Angeles, Denver, Chicago, Detroit, New York, Washington}\}$ and a set of edges $E = \{e_1, e_2, e_3, e_4, e_5, e_6, e_7, e_8, e_9\}$.

Based on the direction of the edges, graph can be distinguished into two types.

1. Undirected Graph

A graph with no direction on its edges. In an undirected graph, the edges e_{12} and e_{21} would be the same since it connects the vertices 1 and 2.

2. Directed Graph

A graph with direction on its edges. In a directed graph, edge e_{12} and e_{21} is different. Edge e_{12} connects node 1 to node 2, while edge e_{21} connects node 2 to node 1.

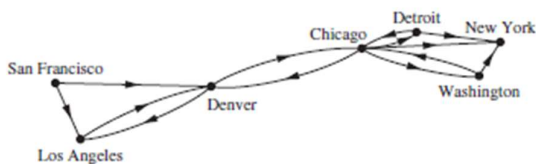


Image 2.2 A directed Graph

(Source: Discrete Mathematics and Its Applications 7th Ed, Kenneth Rosen)

There are some terminologies regarding graph.

1. Adjacent: two vertices connected by one edge.
2. Incidence: a node which is connected to an edge.
3. Isolated node: a node which is not connected to any edge.
4. Null graph: a graph with no edge
5. Degree: a total number of edges that are connected to a node.

B. Tree

Tree is defined as a connected, undirected graph with no circuit. This means that all vertices are connected to at least one other node and node a does not connect to itself.

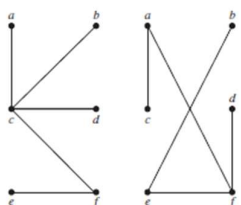


Image 2.3 Tree example

(Source: Discrete Mathematics and Its Applications 7th Ed, Kenneth Rosen)

1. Rooted Tree

Rooted tree is a tree with one node designated as the “root” and the other vertices act as its branch, directed away from the root.

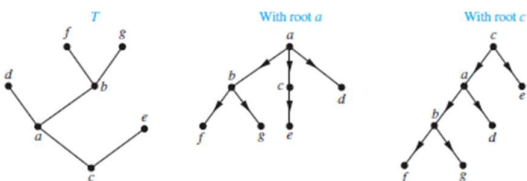


Image 2.4 Rooted tree with different branch

(Source: Discrete Mathematics and Its Applications 7th Ed, Kenneth Rosen)

There are several terminologies in rooted tree.

1. Parent and Child
Node a is parent to node b if a is the predecessor to b.
Node b is the child to node a if node b is the successor to node a.

2. Path
Route to reach a specific node. In Image 2.4 the path from a to f is a, b, f.
3. Sibling
Vertices with the same parents. In Image 2.4 f and g is sibling.
4. Degree
The number of children a node has. The maximum number of all nodes’ degree is the degree of the tree itself.
5. Leaf
Nodes with no children. In Image 2.4 node f, g, e, and d are leaves.
6. Internal Nodes
Nodes which are not root and has children. In Image 2.4 node b is internal node.
7. Level and Height
Level is how low the node is relative to the tree’s root. The root itself has the level 0. While height is the lowest node in the tree. In Image 2.4 both tree with root c has the height 3.

2. N-ary Tree

N-ary tree is a rooted tree with each node has at most N children. For example, a binary tree has at most 2 children and quaternary tree has at most 4 children.

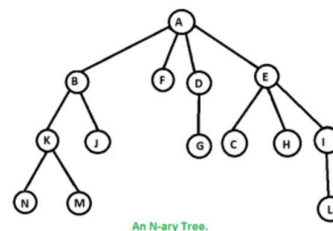


Image 2.5 A ternary tree

(Source: geeksforgeeks.org/number-of-ways-to-traverse-an-n-ary-tree accessed on December 7th 2020)

An n-ary tree with each node has exactly n children is called a complete tree.

3. Decision Tree

A decision tree is a tool to help decision-making problem that uses a tree to represent the choices or decisions and possible outcomes. Each node represents the decisions or choices whereas each edge represents the possible outcomes.

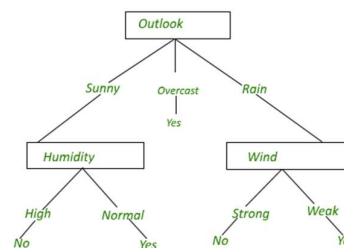


Image 2.6 A decision tree on whether or not to play tennis

(Source: geeksforgeeks.org/decision-tree accessed on December 7th 2020)

C. Persona 4

Persona 4 is a Japanese role-playing game (JRPG) developed by Atlus and the fifth mainline title of the Persona video game franchise. Persona 4 follows a group of high school students who found a mysterious world inside the television, which coincides with an ongoing rumor that missing people seems to appear on a mysterious channel during rainy night. The protagonist, Yu Narukami, is a transfer student in Yasoinaba High School. During his travel to Inaba, he had a weird dream of being visited by a long-nosed man and obtained the power of persona, a physical manifestation of someone's heart. With it, he and his friends decided to investigate the murders that occurred in the town of Inaba.



Image 2.7 Persona 4 game cover

(Source: https://megamitensei.fandom.com/wiki/Persona_4 accessed on December 9th 2020)

In terms of gameplay, Persona 4 can be separated into two parts.

1. Dungeon

This takes place in the TV world. The gameplay here is essentially dungeon crawling, where the player navigates a labyrinth environment or a “dungeon” and fight monsters that are called “shadows.” There are 7 dungeons total in the game, each with different enemies, mini-bosses, and boss. The combat mechanic against the shadows is a turn-based combat. After navigating through the dungeon, the player will have to fight the dungeon boss to clear the dungeon.

2. Daily Life

This takes place in the real world in the town of Inaba. Over the course of the next school year, the player can choose how to manage their time in order to improve their skills or bonds with friends. The player is limited to choose two action each day, one during after school and one during the evening. The player story time is also limited, which dictated by the calendar. There are vital deadlines on what needs to be done so the player needs to carefully choose how they spend the day.

There are some important mechanics in Persona 4 daily life activity, which are as follow.

1. Social Link

The social link is a major mechanic in the game. This represents the protagonist bonds to his friends. Each social links corresponds to an arcana tarot. There are 21 social links in total, and some of them progress automatically along with the story

progression, while others require the player to spend time with them. Ranking up social links will grant certain benefits depending on the arcana. For other members of the Investigation Team, ranking up their social links will give them a new skill for their persona and maxing them out will awaken their ultimate persona. While other social links will only give bonus XP during persona fusion. Each social link has its own availability time.

2. Social Stats

Social stats are the player status that will serve major use in the daily life. They can be increased by performing certain activities in the daily life. For example, choosing the correct answer in class will increase knowledge and working at a daycare will increase understanding. Some certain social links will also increase certain social stats. These social links are school clubs and part-time jobs. There are 5 social stats in the game, each with 5 ranks.

1. Courage
2. Diligence
3. Understanding
4. Expression
5. Knowledge

Some social links will be locked until certain social stats rank is reached, for example the fortune arcana requires rank 5 knowledge to start.

3. Weather

There are 3 types of weather in Persona 4, these are clear, cloudy, and rain. But since clear and cloudy weather acts similarly, this will be explained in two parts.

1. Clear and Cloudy

This is the basic weather. All of the activities are normal and as scheduled. Most social links are only available during this weather. The only difference between the two is how the day looks and the background music.

2. Rain

In this weather, most social links are unavailable. But more importantly, some activities during rainy days gives bonus social stats increase. There is also a certain activity that is only available during the rainy days, which is the Mega Beef Bowl challenge that increases 4 social stats. Some shadows also only available during this weather.

III. THE OPTIMAL WAY TO SPEND DAILY LIFE

A. Generalizing Social Links

As mentioned before, the player can spend the days on clearing the dungeon or ranking up social links and stats. There are 21 social links and to make it easier to choose which social link to rank up first. This will be separated into four types, party members, non-party members, quest, and story.

Person	Arcana	Social Link Type
Yosuke Hanamura	Magician	Party member
Chie Satonaka	Chariot	Party member
Yukiko Amagi	Priestess	Party member
Kanji Tatsumi	Emperor	Party member

Rise Kujikawa	Lovers	Party member
Naoto Shirogane	Fortune	Party member
Kou Ichijo and Daisuke Nagase	Strength	Non-party member (Club)
Yumi Ozawa or Ayane Matsunaga	Sun	Non-party member (Club)
Ai Ebihara	Moon	Non-party member
Naoko Konishi	Hanged Man	Non-party member
Nanako Dojima	Justice	Non-party member
Ryotaro Dojima	Hierophant	Non-party member
Hisano Kuroda	Death	Non-party member
Eri Minami	Temperance	Non-party member (Job)
Sayoko Uehara	Devil	Non-party member (Job)
Shu Nakajima	Tower	Non-party member (Job)
Fox	Hermit	Quest
Margaret	Empress	Quest
The Investigation Team	Fool	Story
Teddie	Star	Story
Seeker of Truth	Judgement	Story

Table 3.1 Social link classification

Party members are the other members of the investigation team. These 6 social links should be the priority because ranking them up will improve their combat ability. The non-party members won't grant any improvement to the combat gameplay therefore it is not a priority. As for the quest, these two social links can be progressed alongside other activity since quests doesn't spend time and advance the day. While story will be automatically progress as the player got further into the game. Based on the paragraph above, party members social links should be prioritized over non-party members. There is also the part-time job and school club classification on the non-party members social links type. These two types can increase certain social stats, therefore should be prioritize over the standard non-party members social links type.

There are two social links that also acts as a quest in Persona 4, The Fox (Hermit) and Margaret (Empress). Margaret will ask the player to fuse certain persona to progress her social links. This can be done by collecting persona when the player is venturing through the dungeon. Therefore, this social link won't be included as a daily life activity. Meanwhile, The Fox will ask the player to talk to certain people and do certain activity. These action mostly don't cost time. However, after finishing these quests, the player needs to turn in to the fox and this action cost time. This social link priority will be different than other social links because it will still be available during rainy days. So, in order to maximize the social links, it is recommended to turn in to fox during rainy days as the other social links won't be available.

B. Social Stats Priority

The social stats priority won't be considered too deeply. In general, the player should try to balance each of the social stats

rank. This is because the social stats requirements for the social links will mostly around the same rank at the given time. There is one party member social link that requires a certain social stat rank to unlock, which is Naoto Shirogane. Although, by the time the player can start her social link, it will be most likely around her requirement. Therefore, the priority for social stats should be to balance each of them.

C. Social Links Decision Tree

In this part, we will construct the decision tree for choosing the social links. The decision tree will be modified as the following rules:

1. Each node will represent a question (oval) or a decision (rectangle).
 2. Each edge will represent the answer to the node's question as a yes or no.
 3. The derivation will be another question or the decision of what action is going to be done.
 4. The decision is the optimal way to spend the day
- Below is the decision tree for choosing the social link.

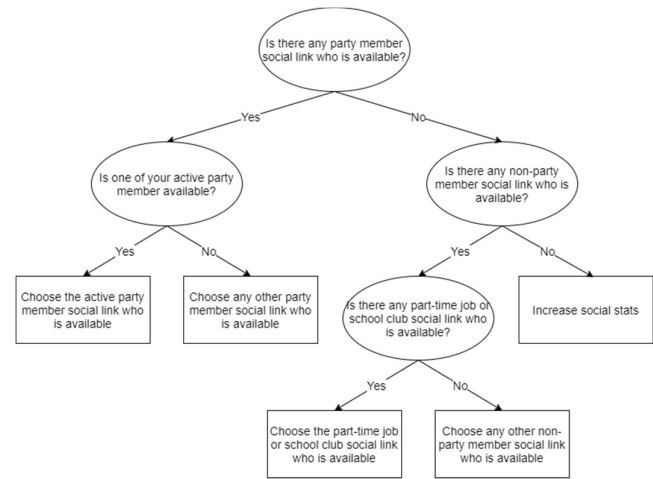


Figure 3.1 Social link selection decision tree

Firstly, we will look for the available party members social links. If there's an available party member social link, we will prioritize the active party member over the inactive one. This is because inactive party members aren't as important as active party member. If there is no party members social links available, we will choose the available non-party members, while prioritizing the part-time job or school club social links. If there is no social links available, the player should increase their social links.

D. Daily Life Decision Tree

In this section, we will construct the daily life decision tree. Firstly, we will need to define the priority on which activity should the player choose first. The priority should be to prioritize clearing the dungeon then rank up the social links then increase the social stats. The reason to prioritize clearing the dungeon first is because if the player doesn't clear it in the given time, it will be game over. Therefore, clearing the dungeon should be the first priority. As for prioritizing social links over social stats, this is because improving social stats won't give any

benefits to the dungeon and combat aspect of the game, while social links will. Additionally, social links requires social stats to progress and some social links increase social stats. Therefore, with prioritizing social links, social stats will increase as well. We will also need to determine the weather of the day since this will change the social links over social stats priority. During rainy weather it is better to spend time to increase social stats because of the bonus it provides. Although, if the player hasn't turned in a completed the Fox quest, the player should turn it in first in order to rank up the Fox social link.

Next up is the social links rank up mechanics. In order for social links to rank up faster, the player needs to choose the correct response on the narrative dialogue. Certain dialogue will grant more "notes," which is used to determine the social links progress. These "notes" only accumulate in one rank, and in each rank up, the "notes" count will reset. In order to maximize time efficiency for social links, we need to prioritize on spending time on those social links who are near rank up. The reason is because there are story segments that will grant bonus notes on some social links which can be a waste if it's near rank up.

With those explanations above, the following priority list is made.

1. Clear the dungeon.
2. If it rains, turn in to fox or increase social stats.

3. If there's party members social links near rank up, spend time on him/her.
4. If there's no party members social links near rank up, check non-party social links that is near rank up.
5. If there's no social links near rank up, check on available party member social link.
6. If there's no party members social links available, check on non-party members social links.
7. If there's no social links available, increase social stats.

After defining the priority list, we construct the decision tree with the same rules as the social links decision tree, which are as follow.

1. Each node will represent a question (oval) or a decision (rectangle).
2. Each edge will represent the answer to the node's question as a yes or no.
3. The derivation will be another question or the decision of what action is going to be done.
4. The decision is the optimal way to spend the day

The decision tree can be seen at the bottom of this page. This decision tree is expanded from the social links decision tree, with the addition of dungeon, weather system, and additional social links priority.

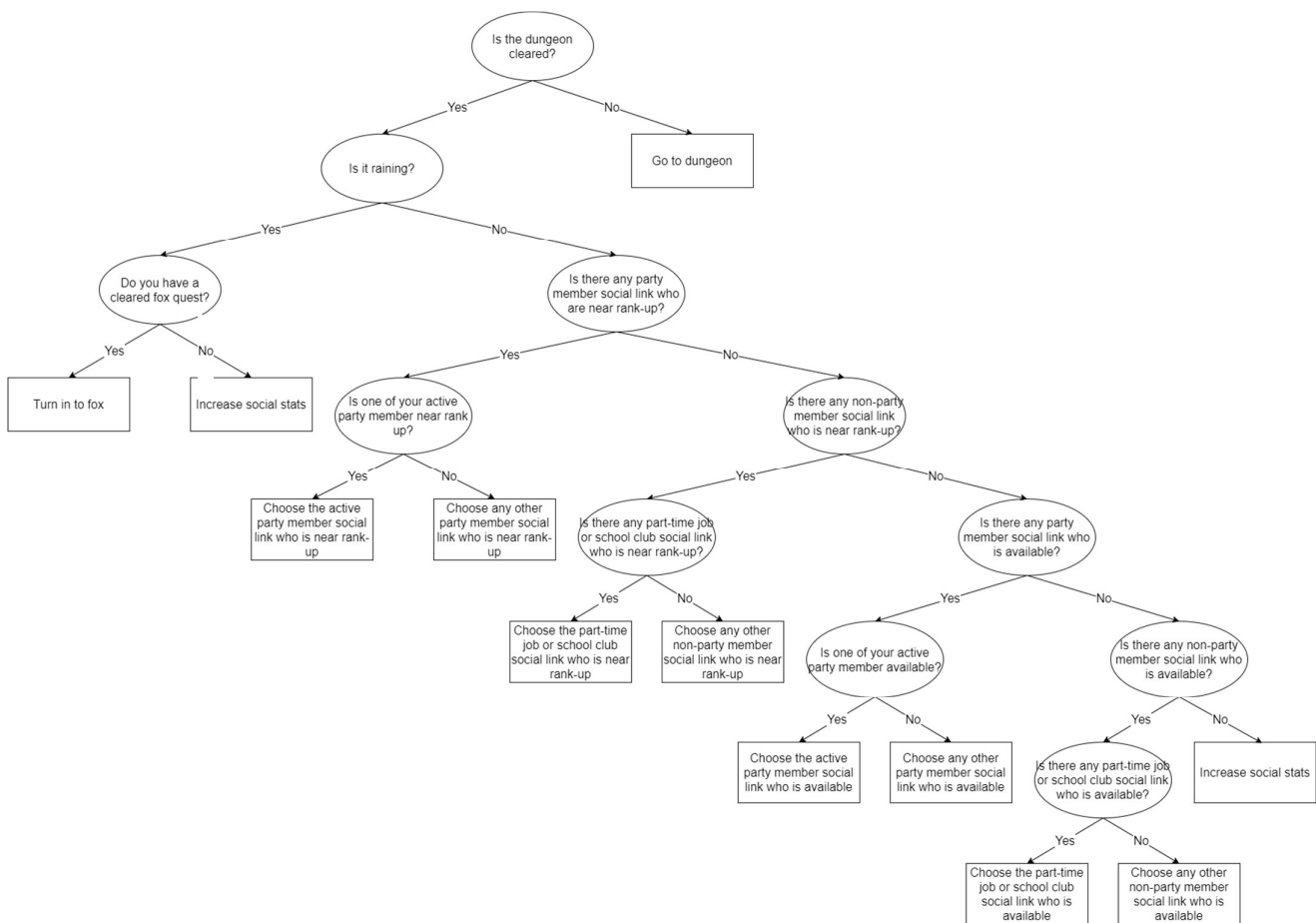


Figure 3.2 Daily life decision tree

IV. CONCLUSION

Graph and Tree has a wide range of variety of uses. This is due to its versatility which can be modified in all sorts of ways to fit our needs. This paper is one of the examples. Although, this example has its limitation, such as it didn't cover all the things in game. This is due to the complexity and the number of choices that can be done in the game. Even so, I am sure with more in-depth analysis of the game, it is possible to make a more detailed and optimized strategy to efficiently spend time on the daily life in this game. With this, I believe that tree can be used to represent even the more complex behavior.

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REFERENCES

- [1] K. H. Rosen, *Discrete Mathematics and Its Application*, 7th Ed. New York: McGraw-Hill, 2012, pp. 641–772.
- [2] <http://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Graf-2020-Bagian1.pdf>, accessed on December 7th 2020.
- [3] <http://informatika.stei.itb.ac.id/~rinaldi.munir/Matdis/2020-2021/Pohon-2020-Bag1.pdf>, accessed on December 7th 2020.
- [4] <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5767274>, accessed on December 7th 2020.
- [5] https://megamitensei.fandom.com/wiki/Persona_4, accessed on December 9th 2020.
- [6] <https://www.fandom.com/articles/japanese-western-rpgs-different>, accessed on December 9th 2020.

PERNYATAAN

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Bandung, 9 Desember 2020



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