Decision Analysis report 1 - PROMETHEE I, PROMETHEE II, ELECTRE TRI-B

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1 Data set

1. What is the domain of the problem about?

   We tackle the problem of determining what video game should be purchased or played

2. What is the source of the data?

   The games' store pages on Steam and DM's judgement

3. What is the point of view of the decision maker?

   The decision maker is a person with a limited budget of time and money who has a particular taste in video games. They wish to find out what titles would be the best to sink their resources into.

4. What is the number of alternatives considered? Were there more of them in the original data set?

   15 alternatives are considered. Originally, there were 8 of them, because one of the author's wishlists contained only 8 games. The decision to include already owned games was a motivated by curiosity, the desire to have more informative results, and the need to have at least 12 alternatives in the data set.

5. Describe one of the alternatives considered (give its name, evaluations, specify preferences for this alternative)

   Representation of one of the considered alternatives - the game "Nebuchadnezzar"

   - Title: Nebuchadnezzar
   - Price: 71.99
   - % of positive reviews: 81
   - Total number of reviews:1085
   - System requirements: 3
   - Content volume: 5
   - Gameplay: 8
   - Audio: 6
   - Graphics: 6
   - Position on wishlist: 1

6. What is the number of criteria considered? Were there more of them in the original data set?

   9 criteria are considered. There were 9 criteria in the original data set as well, since we created it ourselves.

7. What is the origin of the various criteria? (catalog parameter / created by the decision maker - how?)

   `price` - full cost of the game, taken from its Steam store page (given in PLN, for Polish market)

   `positive_reviews_percentage`, `number_of_reviews` - same Steam store page

   `system_requirements` - based on the information given on the Steam store page

   `content_volume`, `gameplay`, `audio`, `graphics` - based on authors' personal judgements

   `position_on_wishlist` - position on one of the author's wishlists.

8. What are the domains of the individual criteria (discrete / continuous)? Note: in the case of continuous domains, specify the range of the criterion's variability, in the case of others: list the values. What is the nature (gain / cost) of the individual criteria?

   All criteria are discrete (even `price`).

   `price` - self explanatory. Minimum value in the data set: 0 (for "Path of Exile", a free to play game), maximum value: 249.00 ("ELDEN RING")

   `positive_reviews_percentage` - 0-100 scale.

   `system_requirements`, `content_volume`, `gameplay`, `audio`, `graphics` are all judged on a 1-10 scale.

   `position_on_wishlist` - 1 represents the top of the list (the most desired game). If already owned, set to 0 - this seemed to be a natural representation and it reflects the DM's preference for this title, which must hold, since they decided to purchase it already.

9. Are all criteria of equal importance (should they have the same "weights")? If not, can the relative importance of the criteria under consideration be expressed in terms of weights? In this case, estimate the weights of each criterion on a scale of 1 to 10. Are there any criteria among the criteria that are completely or almost invalid / irrelevant?

   No, the criteria are not of equal importance. Here are the estimated criteria weights:

   - `price` 7
   - `positive_reviews_percentage` 10
   - `number_of_reviews` 5
   - `system_requirements` 6
   - `content_volume` 6
   - `gameplay` 8
   - `audio` 3
   - `graphics` 4
   - `wishlist_position` 6

   The `audio` and `graphics` criteria are of particularly low importance. The authors do not consider them vital to a good experience, but rather additional means of enhancing it.

10. Are there dominated alternatives among the considered data set? If so, present all of them (dominating and dominated alternative), giving their names and values on the individual criteria.

    Yes, there are 3 dominated alternatives: "Last Epoch" (by "Divinity: Original Sin 2"), Gears Tactics (by "Path of Exile"), and "Superliminal" (dominated by both "Portal 2" and "Terraria")

Criterion	Last Epoch	Divinity: Original Sin 2
Price	161.99	161.99
% of positive reviews	84	95
Number of reviews	15629	139068
System requirements	7	7
Content volume	9	9
Gameplay	9	9
Audio	6	9
Graphics	7	9
Wishlist position	7	0

Criterion	Gears Tactics	Path of Exile
Price	142.99	0
% of positive reviews	75	87
Number of reviews	5873	197422
System requirements	8	7
Content volume	5	11
Gameplay	5	8
Audio	4	6
Graphics	7	7
Wishlist position	8	0

Criterion	Superliminal	Portal 2	Terraria
Price	71.99	45.99	35.99
% of positive reviews	94	99	97
Number of reviews	18197	336314	880572
System requirements	4	2	2
Content volume	4	4	8
Gameplay	6	7	8
Audio	3	8	8
Graphics	5	6	5
Wishlist position	5	0	0

11. What should the theoretically best alternative look like in your opinion? Is it a small advantage on many criteria, or rather a strong advantage on few (but key) criteria? Which?

    An alternative with strong performances on key criteria would be the most preferred. Especially on `positive_reviews_percenta` and `gameplay`, as that would indicate a game that is easy to enjoy.

12. Which of the considered alternatives (provide name and values on individual criteria) seems to be the best / definitely better than the others? Is it determined by one reason (e.g. definitely the lowest price) or rather the overall value of the criteria? Does this alternative still have any weaknesses?

    "Terraria" appears to be a strong candidate for the title of the best alternative. It is very cheap for a full-priced video game in 2023, without sacrificing any qualities expected from an established title, while also being the most popular (by a wide margin) and exceptionally well received. It is also very light on system requirements due to its design choices, but it presents them very elegantly, leading to a decent score in graphics and an iconic soundtrack.

    - Title: Terraria
    - Price: 35.99
    - % of positive reviews: 97
    - Total number of reviews: 880572
    - System requirements: 2
    - Content volume: 8
    - Gameplay: 8
    - Audio: 8
    - Graphics: 5
    - Position on wishlist: 0

13. Which of the considered alternatives (provide name and values on individual criteria) seems to be the worst / definitely worse than the others? Is it determined by one reason (e.g. definitely the highest price), or rather the overall value of the criteria? Does this alternative still have any strengths?

    The game "Gears Tactics" seems to be the worst. It is mostly due to being rather weak across the board, and doing particularly poorly on the cost type criteria (`price` and `system_requirements`). The one redeeming quality are its comparatively good graphics.

    - Title: Gears Tactics
    - Price: 142.99
    - % of positive reviews: 75
    - Total number of reviews: 5873
    - System requirements: 8
    - Content volume: 5
    - Gameplay: 5
    - Audio: 4
    - Graphics: 7
    - Position on wishlist: 8

2 Problem analysis with the use of PROMETHEE I and II

1. Write the preferential information you provided at the input of the method.

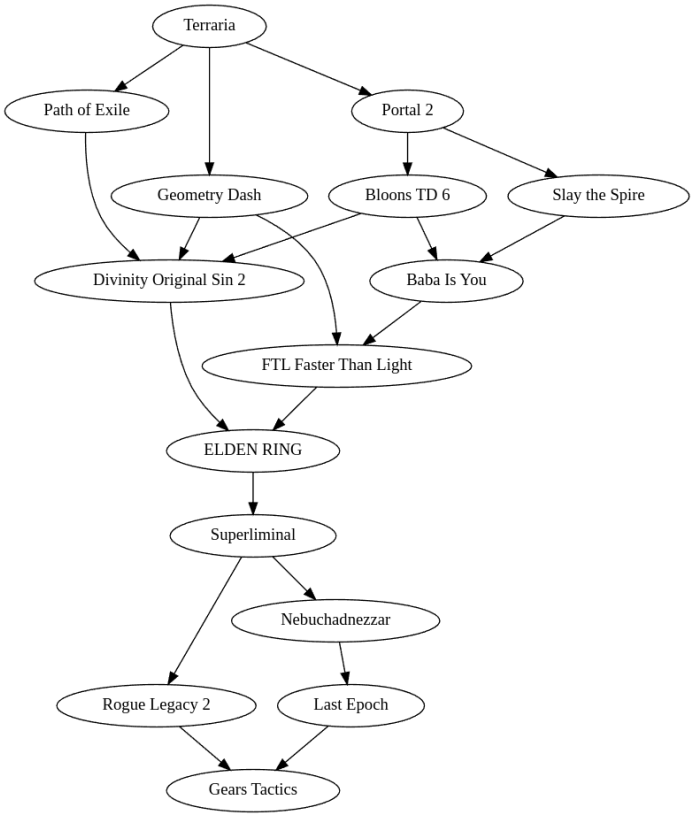
   Raw data available in `./data/games_criteria.csv`

Criterion	Type	Indifference threshold	Preference threshold	Weight
Price	cost	10	20	7
% of positive reviews	gain	5	10	10
Number of reviews	gain	100	10000	5
System requirements	cost	1	3	6
Content volume	gain	1	4	6
Gameplay	gain	2	5	8
Audio	gain	3	7	3
Graphics	gain	2	5	4
Position on wishlist	cost	0	3	6

2. Enter the final result obtained with the method. Usually, the first result is not the final one, you can slightly adjust the parameter values to your preferences.

	GT	FTL	DOS2	T	N	BTD 6	BiY	LE	SL	GD	RL 2	P2	ER	PoE	StS
Gears Tactics															
FTL Faster Than Light	P		?		P			P	P		P		P	?	
Divinity Original Sin 2	P	?			P		?	P	P		P		P		?
Terraria	P	P	P		P	P	P	P	P	P	P	P	P	P	P
Nebuchadnezzar	P							P			?				
Bloons TD 6	P	P	P		P		P	P	P	?	P		P	?	?
Baba Is You	P	P	?		P			P	P	?	P		P	?	
Last Epoch	P										?				
Superliminal	P				P			P			P				
Geometry Dash	P	P	P		P	?	?	P	P		P	?	P	?	?
Rogue Legacy 2	P				?			?							
Portal 2	P	P	P		P	P	P	P	P	?	P		P	?	P
ELDEN RING	P				P			P	P		P				
Path of Exile	P	?	P		P	?	?	P	P	?	P	?	P		?
Slay the Spire	P	P	?		P	?	P	P	P	?	P		P	?	

3. Compare the complete and partial ranking.



1. Terraria
2. Portal 2
3. Geometry Dash
4. Path of Exile
5. Bloons TD 6
6. Slay the Spire
7. Baba Is You
8. FTL Faster Than Light
9. Divinity Original Sin 2
10. ELDEN RING
11. Superliminal
12. Rogue Legacy 2
13. Nebuchadnezzar
14. Last Epoch
15. Gears Tactics

They correspond well to each other, as expected. The complete ranking doesn't capture the full complexity of the relationships, but it gives a faithful "summary" of the results.

4. Comment on the compliance of the results with your expectations and preferences. Refer, among others, to to the results for the alternatives that you indicated as the best and worst during the data analysis. What operations were required to obtain the final result (e.g. changing the ranking of criteria, adding blank cards, changing the value of threshold)?

   The results mostly comply with the expectations. All 4 initial pairwise comparisons are satisfied. Personally, I'm surprised by the good performance of "Geometry Dash". "Terraria" and "Gears Tactics" were good picks for the extreme alternatives - they clearly performed best and worst, respectively. There were few changes to the criteria were made during the process. The thresholds for price were adjusted seeing how poorly some more expensive games were performing despite their other merits. The authors had disagreements about the ratings of particular games, those were the parameters that took the longest to settle down on.

3 Problem analysis with the use of ELECTRE TRI-B

1. Write the preferential information you provided at the input of the method.

   Raw data loaded from `./data/games_criteria.csv`, with weights updated using the SRF method with the following card stack:

   - % of positive reviews
   - Gameplay
   - —
   - Content volume
   - —
   - —
   - Number of reviews
   - wishlist_position
   - —
   - System requirements
   - Graphics
   - —
   - —
   - Price
   - —
   - Audio

Criterion	Type	Indifference threshold	Preference threshold	Veto	Weight
Price	cost	10	20	50	0.045886
% of positive reviews	gain	5	10	40	0.189873
Number of reviews	gain	100	10000	100000	0.123418
System requirements	cost	1	3	7	0.09019
Content volume	gain	1	4	6	0.156646
Gameplay	gain	2	5	7	0.178797
Audio	gain	3	7	–	0.023734
Graphics	gain	2	5	–	0.079114
Position on wishlist	cost	3	7	–	0.023734

   There are 4 decision classes: Bottom, Mid, High and Top Tiers.

2. Enter the final result obtained with the method. Usually, the first result is not the final one, you can slightly adjust the parameter values to your preferences.

Pessimistic Assignment, $\lambda = 0.65$

(a) Top Tier
- FTL Faster Than Light
- Baba Is You
- Bloons TD 6
- Geometry Dash
- Nebuchadnezzar
- Path of Exile
- Slay the Spire
- Terraria
- Superliminal
- Portal 2

(b) High Tier
- Rogue Legacy 2
- Gears Tactics

(c) Mid Tier
- Divinity Original Sin 2
- Last Epoch

(d) Bottom Tier
- ELDEN RING

Optimistic Assignment, $\lambda = 0.65$

(a) Top Tier
- FTL Faster Than Light
- Baba Is You
- Bloons TD 6
- Geometry Dash
- Nebuchadnezzar
- Path of Exile
- Slay the Spire
- Terraria
- Superliminal
- Portal 2
- Rogue Legacy 2
- Divinity Original Sin 2
- Last Epoch
- ELDEN RING

(b) High Tier
- Gears Tactics

(c) Mid Tier
- <empty>

(d) Bottom Tier
- <empty>

3. Comment on the compliance of the results with your expectations and preferences. Refer, among others, to to the results for the alternatives that you indicated as the best and worst during the data analysis. What operations were required to obtain the final result (e.g. changing the ranking of criteria, adding blank cards, changing the value of threshold)?

   Top Tier seems a bit too inflated in both cases. This could be mitigated by adjusting the boundary to be less accessible, or adjusting the weights (perhaps there is some pattern in the data that makes it easy to fit everything into that one particular class).

   The results are relatively pleasing – especially the pessimistic assignment. ELDEN RING sits at rock bottom, probably due to its unfavorable price tag. A lot of more accessible games are above it. It is a bit surprising that Divinity Original Sin 2 is only in the Mid Tier, considering its incredibly high values on most criteria, except the price.

   We played with the threshold a bit to see if these results could be tweaked, but there wasn't much observable difference – I believe it's due to a lot of these assignments being dictated by discordance.

4. Compare the optimistic and pessimistic class assignments.

   When moving from pessimistic to optimistic metric, most titles get moved to the Top Tier. Interestingly, this happens to all alternatives below High Tier, yet Gears Tactics stays in High Tier. Perhaps it loses major points on one of the criterions, which successfully prevents it from being promoted up.

5. Comment on the compliance of the results with your expectations and preferences. Refer, among others, to to the results for the alternatives that you indicated as the best and worst during the data analysis. What operations were required to obtain the final result (e.g. changing the ranking of criteria, adding blank cards, changing the value of threshold, boundaries or the λ parameter)?

   Already answered in 3.

6. Second iteration of problem solving

   Let's artificially assign low weights to everything except the price, to simulate a buyer motivated only by their wallet:

Criterion	Type	Indifference threshold	Preference threshold	Veto	Weight
Price	cost	10	20	50	0.84
% of positive reviews	gain	5	10	40	0.02
Number of reviews	gain	100	10000	100000	0.02
System requirements	cost	1	3	7	0.02
Content volume	gain	1	4	6	0.02
Gameplay	gain	2	5	7	0.02
Audio	gain	3	7	–	0.02
Graphics	gain	2	5	–	0.02
Position on wishlist	cost	3	7	–	0.02

The new grouping presents itself as follows:

Pessimistic Assignment, $\lambda = 0.65$

(a) Top Tier
- FTL Faster Than Light
- Baba Is You
- Geometry Dash
- Path of Exile
- Terraria
- Bloons TD 6
- Portal 2

(b) High Tier
- Slay the Spire
- Superliminal
- Nebuchadnezzar

(c) Mid Tier
- Rogue Legacy 2
- Divinity Original Sin 2
- Last Epoch
- Gears Tactics

(d) Bottom Tier
- ELDEN RING

Optimistic Assignment, $\lambda = 0.65$

(a) Top Tier
- FTL Faster Than Light
- Divinity Original Sin 2
- Baba Is You
- ELDEN RING
- Last Epoch
- Geometry Dash
- Path of Exile
- Slay the Spire
- Terraria
- Bloons TD 6
- Portal 2

(b) High Tier
- Superliminal
- Rogue Legacy 2
- Nebuchadnezzar

(c) Mid Tier
- Gears Tactics

(d) Bottom Tier
- <empty>

Now, these results aren't the same as sorting by price, because the veto thresholds operate independently from the comprehensive concordance index. That is why we still have some "unintuitive" assignments, like ELDEN RING being in the Top Tier despite being the most expensive alternative. This only proves that ELECTRE TRI-B is a flexible tool, but at the same time suffers from having many moving parts, all of which are the responsibility of the Decision Maker to tweak.

4 Comparing method results

PROMETHEE I yielded the most satisfactory results. Its graph representation is intuitive and rich in information. The PROMETHEE methods also reacted very predictably to changes made to criteria and alternatives. The same was not true for ELECTRE - with so many knobs to turn, which were also a bit less obvious from a user's point of view, the changes sometimes brought about unforeseen consequences. This entire experiment demonstrated that the quality of the results greatly depends on DM's understanding of the algorithm itself, which can be problematic.

By the nature of taking on different types of decision problems, the results of the methods are clearly different, but they don't contradict each other. Some alternatives were consistently favoured (Terraria, Path of Exile, Portal 2), while some (Gears Tactics, Last Epoch) did not receive similar praise.