Universitat Rovira i Virgili

MCDA: Online Store of Films

First Part

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MCDA Problem Definition

Problem Definition

The problem to deal with is an online store for films, the variables considered by the decision maker may be several and not always they are numerical values. In IMDB (Internet Movie Data Base) there are many variables to evaluate a movie. There is a ranking of all the movies according to one criterion, evaluation of users, but they do not consider more criteria to rank movies, because this dynamic database is just oriented to querying movies.

The variables which belong to a movie are the shown in the Figure 1. Many of them do not have a numerical value, or they do not have it, at least in a common way.

For example the title may be important to select a movie, but titles do not have a value associated to them. So the value may exhibit how the title likes the decision maker. This approach may be adopted by other variables.

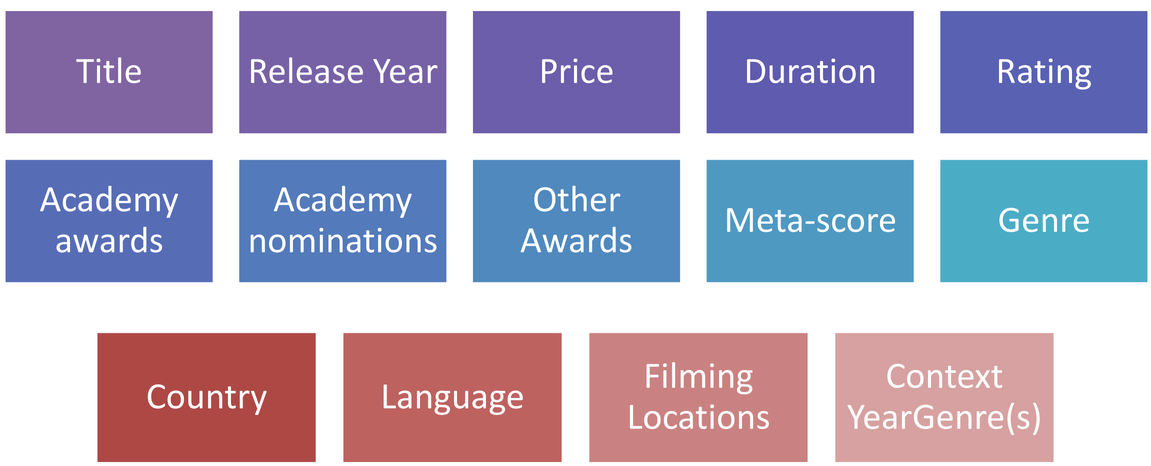


Figure 1 Movie Features

Description of Selected Criteria and Alternatives

- The title is very difficult to analyze amongst others, but even though it will be considered as a criterion with a value which expresses how does it likes to the decision maker.
- Release year is an important criterion; selection of a movie may be directed by the year in which it was released, so it will be considered. Context year is the year in which the movie develops its argument, but this criterion will not be considered because it is difficult to obtain, even in the databases.
- Price, duration, number of academy awards won, number of academy nominations and number of other awards are numerical variables and its use do not represent any problem, but also important information to recommend a movie, so they will be considered in one criterion named awards.
- Meta-score and rating are similar, both refer to a kind of qualification to the movie, but the Meta-score is given by critics of experts in movies and the other by common users, the

recommendation of a movie may be based also in the opinion of others so this variables will be considered.

- Country, language and filming Locations are also variables which could be considered with a numerical value which represents the degree of satisfaction of the decision maker according to the value the variables take for each alternative, even thought is difficult to set this numbers by the decision maker, because some movies belong to more than one country, are filmed in different languages and its locations are not well determined in databases.
- Genre of the movie is important for the decision maker, and as title its value will exhibit the preference of the decision maker in each genre. Even when there are movies with several genres, it will be considered the one which predominates.
- Selected alternatives are the following, which belong to different genres.

Romantic	1. The Notebook
Thriller	2. Pulp Fiction
Adventure	3. Frozen
Animation	4. Lion King
Crime	5. Elite Squad
Comedy	6. Home Alone
Action	7. Lord of War
Drama	8. Silver Linings Playbook
Science Fiction	9. Star Wars
Horror	10. The Conjuring

Performance Matrix

Alternative	Title	Genre	Release Year	Price	Duration	Rating	Meta-Score	Awards
1	6.0	3.0	7.0	9.99	123.0	8.0	53	11
2	9.5	8.0	8.0	9.99	154.0	9.0	94	63
3	7.5	8.5	8.0	14.99	102.0	7.9	54	37
4	8.0	7.0	8.0	27.39	89.0	8.5	83	29
5	7.0	7.5	7.0	9.99	115.0	8.1	33	30
6	6.0	7.0	7.0	9.99	103.0	7.4	63	12
7	7.5	7.0	7.0	9.99	122.0	7.6	62	1
8	4.0	6.0	8.0	9.99	122.0	7.9	81	70
9	10.0	9.0	5.0	39.96	121.0	8.7	91	45
10	6.0	2.0	8.0	10.99	112.0	7.6	68	4

Table 1 Performance Matrix

Criteria Thresholds and Weights

	Title	Genre	Release Year	Price	Duration	Rating	Meta-Score	Awards
Weights	0.05	0.15	0.05	0.15	0.05	0.20	0.20	0.15
Ind.	6.0	5.0	6.0	0.0	0.0	7.0	70	0
Pref.	8.0	9.0	8.0	10.0	130.0	9.0	90	3
Veto	-	3.0	-	15.00	180.0	4.0	40	-
Direction	Max.	Max.	Max.	Min.	Min.	Max.	Max.	Max.

Table 2 Criteria Thresholds and Weights Table

Almost all of the information of the performance matrix was taken from IMDb website (Amazon, IMDb.com, Inc., 1990), except prices which has been taken from Amazon (Amazon, Amazon.com, Inc., 1996) website and meta-score from Metacritic website (Interactive, 2014). The criteria which are measured in a range from one to ten are rating, title, genre and release year, and meta-score from one to one hundred. Prices are in dollars and duration in minutes as it is possible to consider values combined with decision maker preference values. Weights, titles, genre, release year and thresholds are values, given by the preferences of the decision maker.

Year criterion has a preference value from 1 to 10 for different year intervals:

- 1970-1980 preference value=5
- 1981-1990 preference value=8
- 1991-2000 preference value=8
- 2000-2010 preference value=7
- 2010-2014 preference value=8

MCDA Procedure

Multicriteria problems are those in which have a set of finite alternatives and a set of criteria to evaluate those alternatives. There is no objection to consider some criteria to be maximized and the others to be minimized. The expectation of the decision-maker is to identify an alternative optimizing all the criteria.

Usually this problem does not have an alternative which optimizes all the criteria at the same time. However most (nearly all) human problems have a multicriteria nature. According to our various human aspirations, it makes no sense, and it is often not fair, to select a decision based on one evaluation criterion only. In most of cases at least technological, economical, environmental and social criteria should always be taken into account. Multicriteria problems are therefore extremely important and request an appropriate treatment.

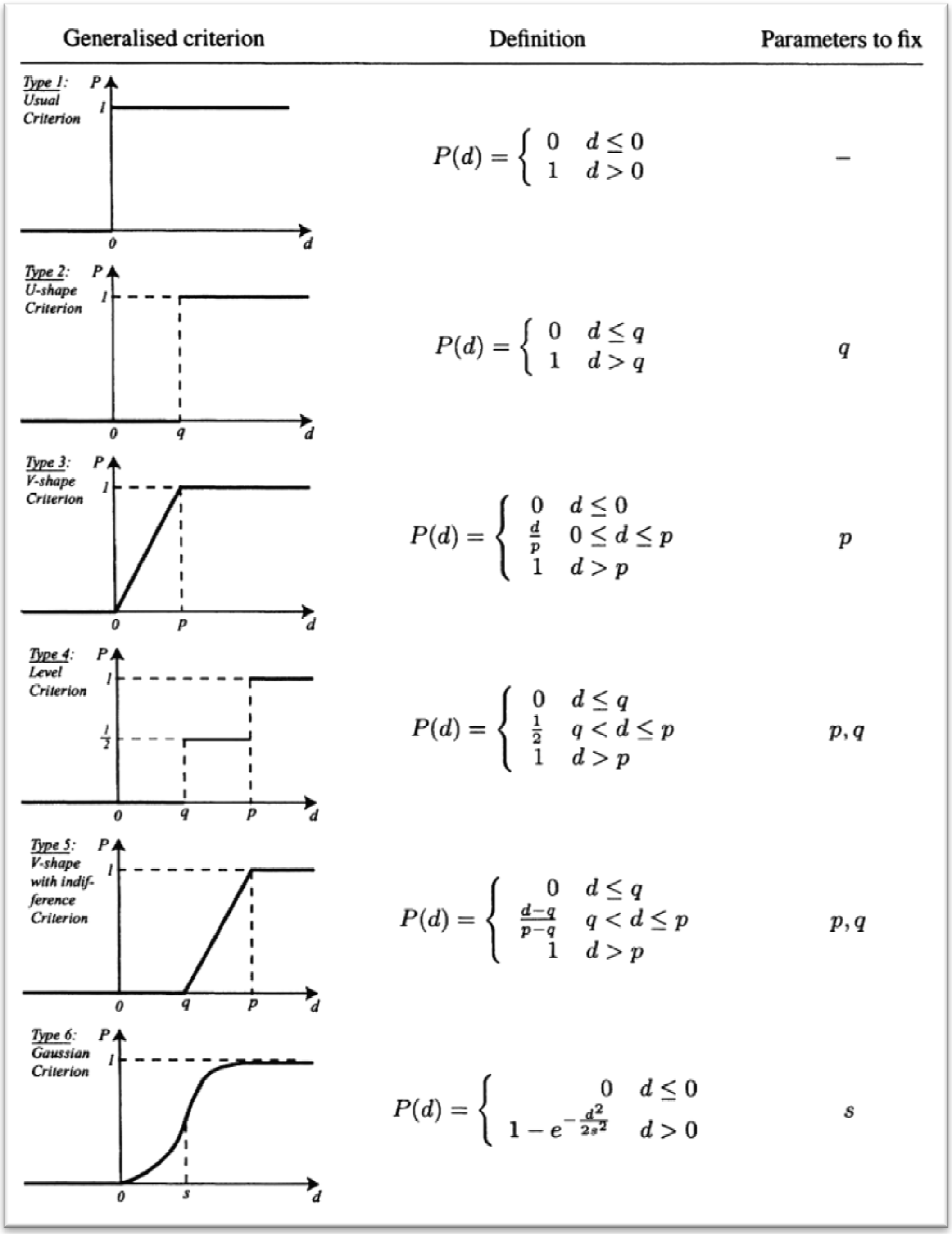
Considering the problem above, the solution not only will depend on the basic data included in Table 1, but also on the Table 2 which reflects completely the individual preferences of the decision maker. There are several methods which allow you to perform decision aid, considering the information contained in those tables. These data has been adapted to work with PROMETHEE method, which consider two kinds of information:

- Information between the criteria
- Information within the criteria

The information between the criteria is represented by a set of weights of relative importance associated with each criterion $\{w_j, j = 1, 2, \dots, k\}$ these weights are non-negative numbers, independent from the measurement units of the criteria. If the weight is higher, then the criterion will be more important and all of them satisfy that $\sum_{j=1}^{k} w_j = 1$.

The information within the criteria refers to the fact that PROMETHEE does not allocate an intrinsic absolute utility to each alternative, but also is based on pairwise comparisons. In this case, the deviation between the evaluations of two alternatives on a particular criterion is considered. If the deviation is large then the preference is large either.

To describe this preferences is used a preference function $P_j(a, b) = F_j\left[d_j(a, b)\right] \forall a,\ b \in A$, where $a, b$are alternatives that belong to a set of alternatives A. And where $d_j(a, b) = g_j(a) - g_j(b)$ and for which $0 \leq P_j(a, b) \leq 1$, being g_j a criterion of an alternative. It works for the criterion when it is maximized, the function should be reversed or alternatively given by $P_j(a, b) = F_j[-d_j(a, b)]$ if the criterion is going to be minimized. The shape may also vary, there are six types proposed for preference functions (Image 1).



Generalised criterion	Definition	Parameters to fix
Type 1: Usual Criterion	$P(d) = \begin{cases} 0 & d \leq 0 \\ 1 & d > 0 \end{cases}$	–
Type 2: U-shape Criterion	$P(d) = \begin{cases} 0 & d \leq q \\ 1 & d > q \end{cases}$	q
Type 3: V-shape Criterion	$P(d) = \begin{cases} 0 & d \leq 0 \\ \frac{d}{p} & 0 \leq d \leq p \\ 1 & d > p \end{cases}$	p
Type 4: Level Criterion	$P(d) = \begin{cases} 0 & d \leq q \\ \frac{1}{2} & q < d \leq p \\ 1 & d > p \end{cases}$	p, q
Type 5: V-shape with indifference Criterion	$P(d) = \begin{cases} 0 & d \leq q \\ \frac{d-q}{p-q} & q < d \leq p \\ 1 & d > p \end{cases}$	p, q
Type 6: Gaussian Criterion	$P(d) = \begin{cases} 0 & d \leq 0 \\ 1 - e^{-\frac{d^2}{2s^2}} & d > 0 \end{cases}$	s

Image 1 Preference Functions

PROMETHEE implementation in diviz uses the type 3, in each case may be defined some parameters, which are q (a threshold of indifference), p (a threshold of strict preference) and a value s (intermediate between value q and p).

After the evaluation table is given, the weights and the generalized criteria are defined for a set of alternatives; the PROMETHEE procedure can be applied.

Data Mapping

To work with PROMETHEE implementation in diviz, data must be mapped to xml format, the definition of this standard is in the official website.

Alternatives

The xml representation of the alternatives contains *id*, *MCDA concept* and *name*. The id must be unique and the name may be related to the alternative, the *MCDA concept* is not used here, the result is the example of an alternative in the Figure 2.

```
<alternative
   id          = TheNotebook
   name        = The Notebook
   >
</alternative>
```

Figure 2 Example of Alternative

Criteria

In this case, inside of the label criteria in xml, may be several criteria, each one under the label *criterion*, the structure is shown in Figure 3, the same as the alternatives it has *id* and *name*. The data inside the label preference direction indicates the direction in which the preference function must be optimized, max for maximization and min for minimization. The data inside the threshold label contains the thresholds which indicate the MCDA concept: *ind* for indifference, *pref* for preference and *veto* for veto.

```
<criteria>

<criterion id = "Title" name = "Title" >
   <scale><quantitative>

   <preferenceDirection>max</preferenceDirection>

   <thresholds>
         <threshold mcdaConcept="pref">
               <constant>
                     <real>8.0</real>
               </constant>
         </threshold>
   </thresholds>

</criterion>
```

Figure 3 Example of Criterion Title

Performance Table

This is a simple xml file which contains the *id* of criteria and alternatives, and the values of each criterion. An example of the same movie than in the first example and the same criterion is shown in Figure 4.

```
<performanceTable>

<alternativePerformances>
    <alternativeID>TheNotebook</alternativeID>
      <performance>
        <criterionID>Title</criterionID>
          <value>
            <real>6.0</real>
          </value>
    </performance>
</performanceTable>
```

Figure 4 Example of Performance Table

Weights

With the weights is a similar structure as in the performance matrix, referring to the criteria, it is used the label *criteria values* with *MCDA concept* attribute equals to the value *importance*. And also the label *criterion value* which contains the information about the criterion and its weight Figure 5.

```
<criteriaValues mcdaConcept="Importance" name="significance">

   <criterionValue>
     <criterionID>Title</criterionID>
       <value>
          <real>0.05</real>
       </value>
   </criterionValue>

</criteriaValues>
```

Figure 5 Example of Weights

PROMETHEE Workflow on Diviz

The implementation of PROMETHEE in Diviz allows you to use different flow methods to determine the ranking of the alternatives, PROMETHEE I (Image 3) which performs a partial ranking and PROMETHEE II (Image 2) which performs a complete ranking. PROMETHEE

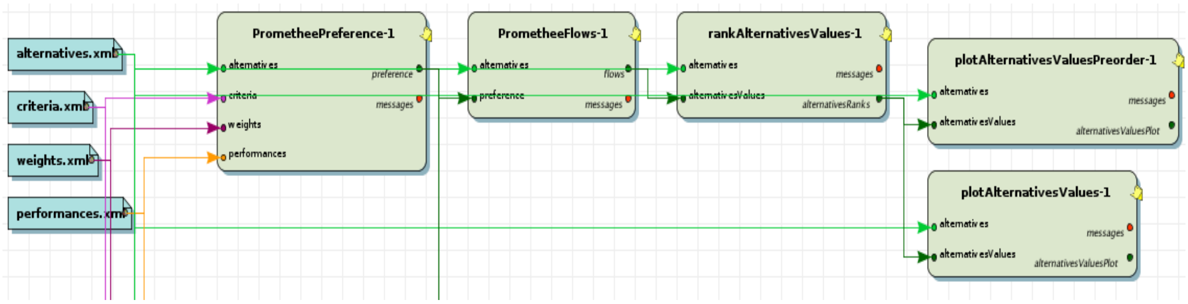


Image 2 PROMETHEE II Workflow

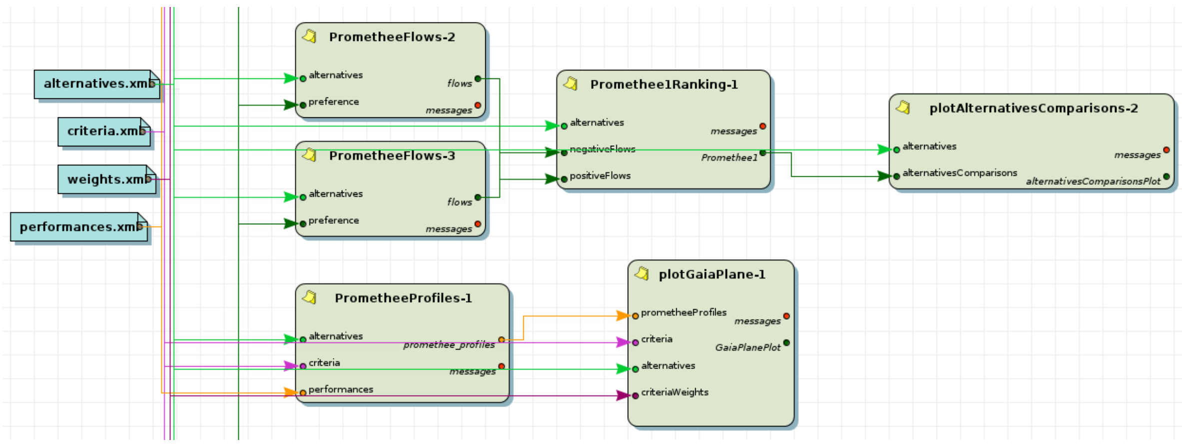


Image 3 PROMETHEE I Workflow

As it was mentioned before, PROMETHEE is based on pairwise comparisons, in order to describe these outranking relations are defined the outranking flows.

Outranking Flows

Each alternative a is compared with the other alternatives in A. The positive outranking flow is defined as $\varphi^{+}(a) = \frac{1}{n-1}\sum_{x \in A}\sum_{j=1}^{k} P_j(a,x)w_j$ which expresses how an alternative a is outranking all the others and represents the power of the alternative, and the negative outranking flow is defined as $\varphi^{-}(a) = \frac{1}{n-1}\sum_{x \in A}\sum_{j=1}^{k} P_j(x,a)w_j$ it expresses how an alternative a is outranked by all the others and represents the weakness.

PROMETHEE I Partial Ranking

In this method, the ranking is obtained intersecting both positive and negative outranking flows, since these outranking flows not usually induce the same rankings.

$$\begin{cases} aP^{I}b \; iff \begin{cases} \varphi^{+}(a) > \varphi^{+}(b) and\ \varphi^{-}(a) < \varphi^{-}(b), or \\ \varphi^{+}(a) = \varphi^{+}(b) and\ \varphi^{-}(a) < \varphi^{-}(b), or \\ \varphi^{+}(a) > \varphi^{+}(b) and\ \varphi^{-}(a) = \varphi^{-}(b); \end{cases} \\ aI^{I}b \; iff\ \varphi^{+}(a) = \varphi^{+}(b) and\ \varphi^{-}(a) = \varphi^{-}(b); \\ aR^{I}b \; iff \begin{cases} \varphi^{+}(a) > \varphi^{+}(b) and\ \varphi^{-}(a) > \varphi^{-}(b), or \\ \varphi^{+}(a) < \varphi^{+}(b) and\ \varphi^{-}(a) < \varphi^{-}(b); \end{cases} \end{cases}$$

Where P^I, I^I, R^I respectively stand for preference, indifference and incomparability, this method will not decide which action is best in the case of incomparable alternatives, it is up to the decision-maker.

PROMETHEE II Complete Ranking

When decision maker requires a complete ranking, the method net outranking flow method is considered in which $\varphi \ (a) = \varphi^+(a) - \varphi^-(a)$ is the balance between positive and negative outranking flows, the higher the net flow, the better the alternative. When this method is considered, all the alternatives are comparable, incomparabilities does not remain and the result can be more disputable.

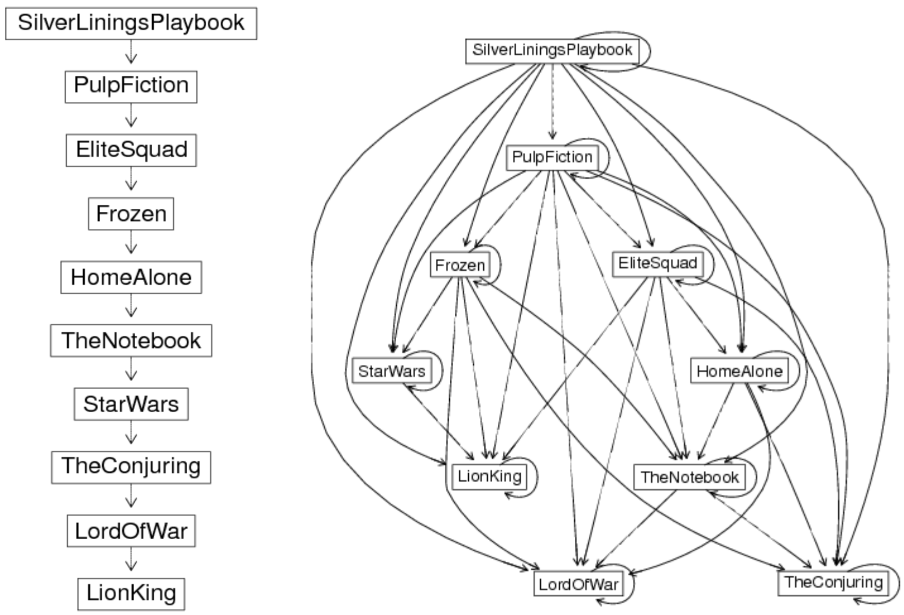
Results and Conclusions

In order to get more information, both methods PROMETHEE I and PROMETHEE II were used. The result of PROMETHEE II is the one shown in Image 4 a). Let's analyze the case of Lion King and Home Alone positions in the flows; Home Alone Net Flow value is higher than Lion King Net Flow value, almost all criteria values from Lion King are better than Home Alone, but there is a veto of 15 euros in price criterion so this alternative is penalized as it has a price of 27.39 euros, and goes below Home Alone.

Another interesting case is Silver Lining Playbook with the best net flow value, which has bad punctuation in title and genre according to the decision maker preferences, but as long as it has a high number of awards and a good punctuation of meta-score and rating, and these are the criteria with the higher weights, it achieves the highest position in the ranking. Pulp Fiction could be better than Silver Linings Playbook as it has also good punctuation in each criterion, even in title and genre, but the duration preference value is set in 130 (this is an important criterion for the decision maker, according to the weights) and this value is closer to Silver Lining Playbook with 122 minutes than Pulp Fiction with 154 minutes.

Alternatives	Positive Flow	Negative Flow	Net Flow
Silver Lining Playbook	0.19	0	0.19
Pulp Fiction	0.18	0.03	0.15
Frozen	0.15	0.11	0.04
Elite Squad	0.12	0.07	0.05
The Notebook	0.08	0.12	-0.04
Lord of War	0.04	0.15	-0.11
The Conjuring	0.06	0.17	-0.11
Star Wars	0.13	0.19	-0.06
Lion King	0.1	0.21	-0.11

Table 3 Positive and Negative Flow



a) **PROMETHEE II** b) **PROMETHEE I**

Image 4 PROMETHEE Ranking

In Image 4 b) is shown the ranking made by PROMETHEE I, here can be observed the incomparability between alternatives with the absence of links between them. The graphic is structured by levels; the first level film does not have an alternative which outranks it, the next level may have one alternative which outranks it, the following two and this way until the last level which has the highest number of outranking relations.

Analyzing the same case, Home Alone and Lion King in this ranking, it can be said that Lion King is one level below Home Alone because Lion King is outranked by five alternatives and Home Alone by three, however there is no link between them, so they are incomparable and it is up to the decision maker to decide which of them is preferred.

Using the PROMETHEE I and PROMETHEE II is clear the recommendation must be Silver Linings Playbook, but if a recommendation of the better alternatives is required I would suggest Silver Linings Playbook, Pulp Fiction, Frozen and Elite Squad as they remain being the better alternatives in both ranking methods.

In order to have a better interpretation of the results, it is used the Gaia interactive module in diviz. Given a k dimensional space in which k is the number of criteria, Gaia performs a principal component analysis to choose which plane is better to project the data in. After the execution of this module some data get lost so the delta parameter shows the quantity of information that is preserved.

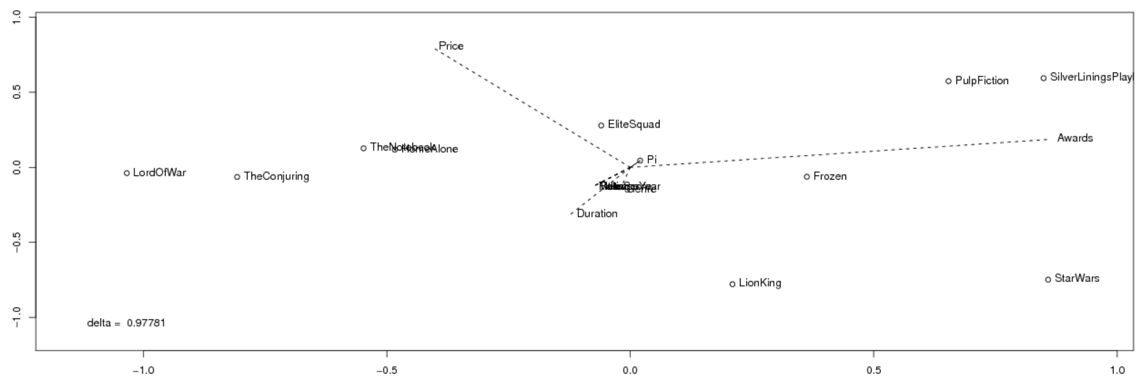


Image 5 represents Gaia plane of the criteria space of the store of films, it can be observed that dots represent the alternatives and the axes represent the criteria, the longer the axes, the more important they are, examples of this are Price, Awards and Duration. The axes are directed, so if an alternative is in the opposite direction means it has lower punctuation in this criterion. Lord of War, The Conjuring, Home Alone and The Notebook are in the opposite direction of Awards criterion, Pulp Fiction, Star Wars and Silver Linings Playbook have a lot of awards and they are in the same side.

The other criteria are strongly correlated because the axes of them are in the same direction, this is good to discriminate criteria but as long as the data set is not extensive you have the risk of discriminate a criterion that is important but is not well represented in the data.

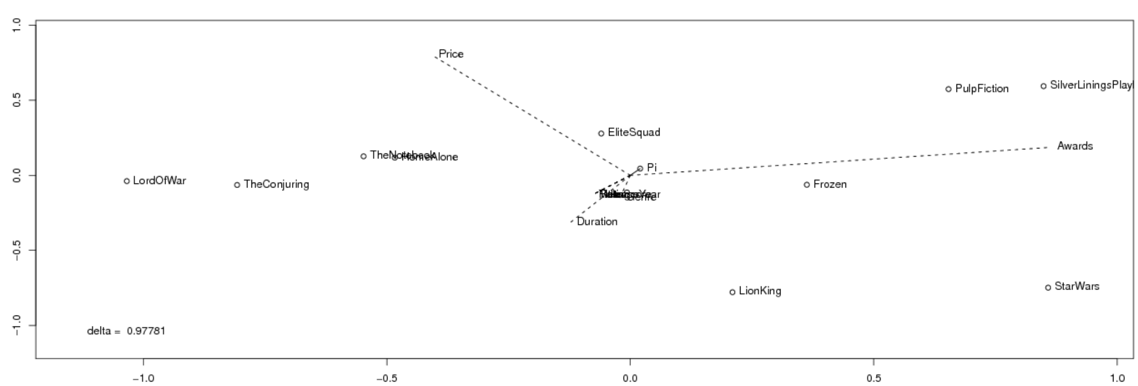


Image 5 Gaia Plane

To sum up, PROMETHEE II is simply to make an interpretation but it has not clear the incompatibilities between criteria, and PROMETHEE I gives information about the incompatibilities but it does not deal with them, the decision maker has to do that. And Gaia plane gives a better understanding of the data globally.

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