The *Castells* crews Multi-criteria Recommender System

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Abstract

The aim of this project is to propose a RS[1], for aiding users willing to join a *Castells*[2] *crew*[3]. The data for defining the criteria was mainly gathered from (BDCJ).

In order to present a possible "real" application of the knowledge extracted, by the research performed. This paper, also, presents all the definitions and new evaluation metrics, together with the reasoning on the relevant decisions taken, during the RS design process. Finally, it proposes some tests on the crew multicriteria recommender system designed, which uses the knowledge extracted during the research and modelling process, in order to calculate the input criteria.

The approach presented in this paper implements the *ELECTRE III method* (Roy, 1978), which retrieves a rank on the alternatives evaluated, according to a given the user profile.

Keywords: Recommender system, "Castells", "Casteller" crew, Multi-criteria, ELECTRE III method.

1. Problem statement and goals

"Castells", also known as "human towers", are one of Europe's most genuine and unique cultural displays. "Castells" are an excellent way of showcasing Catalonia to the world. Watching or taking part in a "castells" display is a thrilling experience that really highlights under a single project the individual and collective struggle for improvement, the effort involved in achieving a goal, the solidarity and spirit of cooperation between people of all ages, conditions and abilities. Moreover, on November the 16th 2010, UNESCO[4] approved the inscription of "castells" on the Representative List Of the Intangible Cultural Heritage of Humanity, giving then a universal recognition to this element (cccc).

1.1. Glossary

Since there is a huge register of concepts exclusively related to the "castells" field. In this section some important concepts are being described in order to provide an initial knowledge on the vocabulary used in this paper.

- "Human towers": is the official translation of "castells" to English (HumanTower). Therefore, derived words will also be translated this way.

1. Recommender System
3. Group of people forming a team that plays "Castells".
4. United Nations Educational, Scientific and Cultural Organization

  - "Human towers player" $\rightarrow$ "Casteller".
  - "Human tower" $\rightarrow$ "Castell".
  - "Human towers crews" $\rightarrow$ "Colles Castelleres" or "Castells crews".

- "Crown" a human tower: Once the "castell" is raised, a member of the crew (typically a small boy or girl) has to put his hand up at the top of the structure.
- "Unloaded" human tower: After being crowned, it is dismantled stage by stage until the "ground layers"[5]. In order to be considered a correct "unloading" it must be done in an ordered way (e.g. without jumping several layers at once).
- "Loaded" human tower: During the "unloading" process, the human tower falls before reaching the "ground layers".
- "Tried" human tower: During "loading" process (before the "crowning") the human tower falls.
- "Unloaded-trial" human tower: The crew is able to perform the "unloading" process, however the "crowning" was not performed. This last one reefers to a successful withdrawing, usually performed in order to avoid falling.
- "Gamma extra" (GE) human towers: Although, the human towers are usually considered by layers (e.g. human towers of six layers, of seven layers, etc.), the most difficult constructions are considered as an individual group named "gamma extra".
- "Pillar": The pillars are within the human towers set of constructions, however they receive a differentiated special treatment when being performed, and, moreover their "value" is never correlated with the rest of human towers of the group they belong to (e.g. pillar of four layers, corresponds to the human towers of six layers and the pillar of six layers corresponds to the human towers of eight layers).
- "La Coordinadora de Colles Castelleres de Catalunya" ("CCCC"): The CCCC is the organisation responsible of: looking after the human towers crews shared interests, promoting the human towers, guaranteeing the methodology correctness (e.g. secure measures) of the human towers performances and that the risks are properly covered by adequate insurances.
- "Concurs": Human towers crews, each year, are ranked according to the difficulty on the human towers they performed, within the current year. Moreover, there is each two years a one day special competition, named "Concurs", where all human towers crews play together in Tarragona city (see ConcursCastells). For this competition, they decide how to evaluate the human tower performances. This metrics decided become the official new metrics for the human towers evaluation.

The points table produced for the 26th "Concurs de Castells" edition (2016) has been added to the appendix A, as 4, of this paper, since it has been widely used in this project.

5. depending on height of the human tower, the "ground layers" may differ (see viquipedia)

1.2. Motivation

From this description on the target scenario where this paper is focused. It might be straight forward to grasp some of the main ideas that have motivated this project. Some of these motivations are listed bellow:

- The target scenario activity during the last century, is recorded in a centralised public database.
- The problem faced is represented by current real data.
- This scenario has not been analysed from this perspective before.
- The data gathered for this project might be useful for further researches and studies on the field.
- The topic is a very important culturally representative characteristic of the local area, moreover also internationally recognised as an very valuable cultural tradition.
- Publicising local data as possible sources for high academic studies, rather than using research famous datasets. Which should be intended to serve for testing new methods, since all their properties are already well known, however are of none interest when using well known methods, without any aim rather than learning the applied methods characteristics.

1.3. The target scenario

During the last decades "casteller" crews have shown an exponential growth (i.e. increase in number of performances, people participation and number of crews).

Figure 1 shows the number of human towers performed per year, during the last decades, all performance trials are quantified in this plot (i.e. each bar in the plot represents the number of all *unloaded*, *loaded*, *tried* and *unloaded-trial* human towers, that toke place in the a certain year, which are added together and plotted). From it, it can be observed three different periods of growth:

1. From 1991 to 2002: "castellers" gain popularity and many new crews are created.
2. From 2003 to 2009: the number of performances per year, starts to decrease.
3. From 2010 to 2015: many factors are given that benefit the "castells" popularity again to arise (e.g. the economical crisis, the university "castells" crews growth and the climbing fashion), reaching its best historical moment (this current year 2016 it continues increasing).

This increase in number of performances given by an increment in number of participants on the existing crews and the creation of many new crews. This increment on the number of participants provided the means to many crews to grow and reach the last levels of performance, where many members are needed for the performances.

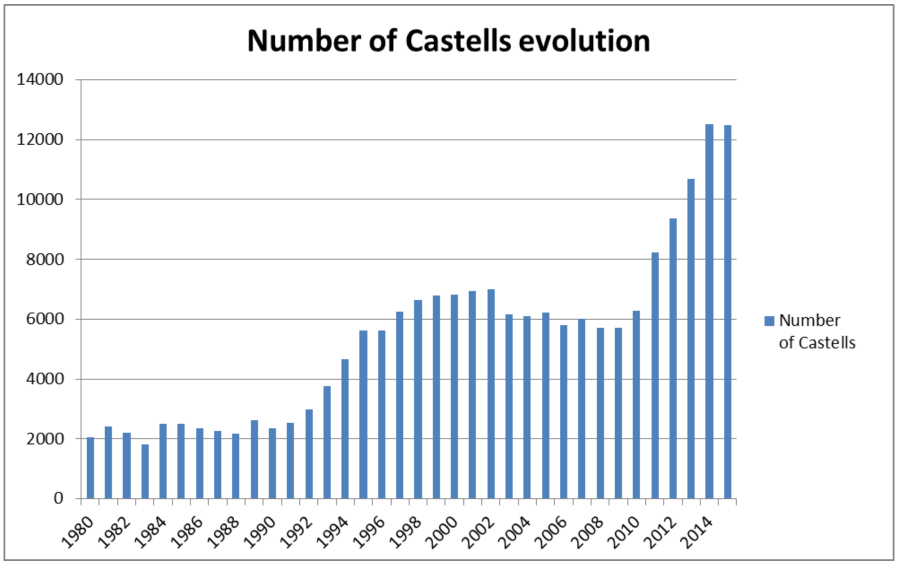

Figure 1: Human towers number of performances evolution over time.

1.4. Contents

In section 2 all related work found, previous analysis and literature regarding the human towers topic, is reviewed, providing an overview on the existing knowledge surrounding this project. Section 3 presents the new dataset created of the *Castells crews* activity, used in this paper. In section 4 the modelling designed for representing the scenario is described. Section 5 illustrates the full process of performing the recommender application using the information extracted during the analysis phase. In section 6 the testing configurations, of the tests performed within this project are discussed. Section 7 presents the discussion on the results obtained from the tests, whose configurations where presented in the previous section 6. In section 8 the possible extensions of this project, together with the strengths and weaknesses analysis of the execution are commented. Finally, in section 9 some concluding remarks, regarding the project, are discussed.

2. Related work

There exist few "serious" (using enough data to be representative and sophisticated statistical methods, rather than just averaging over the results, or retrieving the percentages counted) studies performed within the human towers topic.

After researching exhaustively for related literature concerning other studies performed within the human towers topic, some interesting articles and web sources were found.

In the following part of this section these references are listed and commented.

Articles

- "El risc dels castells" (CCCC, 2011): presents a discussion on the risks of playing human towers.

– "Incidència de lesions en els infants de les colles castelleres de Catalunya" (Pere Godoy und Urtxuletegui, 2011): presents a comparison study on the children injuries, suffered by playing human towers, compared to children who play other sports.
– "Projecte d'estudi de la necessitat, implantació i efectivitat del casc per al pom de dalt" (Rosset und Rovira, 2012): presents a study on the needs for introducing the helmet usasge for the highest positions of the human towers.
– "Les colles castelleres: unes organitzacions singulars" (Botella und Navalpotro, 1998): presents a study on the human and economic resources, and the organisation of human towers players associations.
– "Riesgo de lesión en los castellers a partir del cálculo de la energía potencial" (Jaume Roset Llobet und Orfila, 1997): presents a study on the theoretical injure risk of human towers players considering the potential energy they acquire when climbing the human towers.

Web sources

– "Base de Dades de la Coordinadora de Colles Castelleres de Catalunya – Colla Jove Xiquets de Tarragona" (BDCJ): is the official historical register of all human towers played since 1926.
– "Portal Casteller" (portal): presents a set of interesting statistical tools and direct access to the BDCJ(BDCJ).
– "Ciència i Castells" (cienciaicastells): shows diverse studies performed related to the human towers topic.
– "Viquipèdia-Castells" (viquipedia): actually, is the most complete and updated documentation source referring to the human towers (e.g. human towers history, description of each human tower and human tower crews, are some of the many subtopics documented in viquipedia).

As can be observed from the listed sources above, almost all the studies performed within the human towers topic are related to risk and injuries caused by playing human towers. Thus, it was not possible to consider any previous work related to the aim of this project.

3. The dataset

In order to build the model, the first action to take was to search for all possible data needed, in order to build a reasonable model. Thus, ensuring the utility of the designed model, since the data was already gathered.

For this project a new dataset was created, which collects all the performances activity of the human towers crews from 1990 to 2015.

In order to gather the data for creating the dataset, it was necessary to contact BDCJ and (portal) admins. Which facilitated the data access.

3.1. Format and information

The information is stored as plain text, where each row corresponds to the results from one crew in an specific event. When interpreted in matrix format, columns are separated by the character #, and correspond to the following information:

1. Date (in format: *dd/mm/yyyy*).
2. Location (city name).
3. Name of the event (events where crews play, usually correspond to local festivities).
4. Name of the crew.
5. Record of activity within this event (all trials are recorded, also the unsuccessful ones).

The information regarding the *university crews*[6], which play on a different league, was removed, in order to preserve only relevant information.

The dataset contains all events results recorded within the period from 01/01/1990 to 31/12/2015, accumulation a total of 33314 instances.

4. The model

The aim of this section is to provide a clear understanding on the strategies designed for modelling the target scenario.

The elements and relations that are necessary to be defined in the model are the following:

- The “level” of the crews (i.e. how good they are).
- Time dependence (i.e. temporal model) of the information, the results of just one season, should not be representing full model. Since, the tendency of the results is important to be taken into account.

Other information may be extracted directly from the dataset, without specific processing techniques, rather than the already mentioned (e.g. the information regarding the results can be directly extracted, and does not require a differentiated specification).

In order of being able to analyse the mentioned scenario it is necessary to define a model of these elements and interactions.

Some of the concepts introduced in the model have been designed for modelling the scenario in the most suitable way for solving the target analysis problem.

6. Human towers crews which only play within a university league, but are not able to play with common crews.

The following part of this section presents a discussion on the mentioned new concepts and different possible approaches for improving the initial design of the model.

4.1. The model proposed

In this section the final model considered for this paper is described.

- **Time discretization** → seasons (i.e. correspond to natural years). The period modelled for this project was from 1990 to 2015. Notice that no temporal information will be used for the current evaluation season (i.e. 2016), since seasons are not regular, have an incremental tendency (i.e. crews perform their most difficult constructions by the end of each season). Thus, a non finished season, may not provide real representative information of the overall season results.

- **Temporal representation** → temporal smoothing model (i.e. for every year there will be a model, which will be determined by the results of the previous year, plus, perhaps some features of other previous years). Formally, for a certain season (year) i, the correspondent model, M_i, would be:

$$M_i = w_1 R_{i-1} + w_2 R_{i-2} + w_3 R_{i-3} \tag{1}$$

  , where R_i represents the results obtained on season i, without any temporal smoothing; w_j is a vector of weights, used for computing the influence of each season for each criteria in the evaluation or the current one; and were $w_1 + w_2 + w_3 = 1 \quad \forall {w_j}_{j=1}^{3} \quad 0 \leq w_j \leq 1$. Thus is just an strictly positive weighted sum of the information recorded from the previous three seasons. The decision of using the information of only, at most, the previous three seasons, is due to reduce the undesired outdated information influence.

- **Temporal effect** → the temporal effect is the relevance of the previous records accumulated in the current model. In the formulations presented in this paper, this parameter is represented by w_j. The value decided for this weight will depend on each criteria, since w_j is not a single value, but a vector of weights. However, any weight in w_j will comply that $w_{j-1} \leq w_j$, since the relevance of the previous seasons (i.e. w_2 and w_3) could have a significant presence in the current model, but never greater than newer results from the immediately previous one (i.e. w_1).

5. The recommender system

This section presents the process of designing the RS, once the data has already been obtained, and the model is defined. It can be seen as a real application of the knowledge extracted during the research and modelling phases of this project, reviewed in 4. The presented application is a crew multicriteria RS, which will be feed with a set of alternatives and a user set of preferences on the criteria, and will retrieve a ranking over the alternatives provided.

Note: The presented RS does not intend to provide any ground truth among which crew is better than the others. Moreover, notice that only a subset of the total amount of crews were considered for this paper, in order to simplify the target problem. Thus, the aim of this section is to present an usage case of using real extracted knowledge for feeding a RS.

5.1. Design of the RS

In order to design the RS, the following steps were considered:

1. Decide the criteria to be considered.
2. Choose a the preference representation.
3. Select the algorithm that best fits with the upper two specifications.

5.2. Criteria

Usually, the optimal decision could be optimally using perfect predictions on the future performance of all crews of the alternatives set. However, this information is very difficult to predicted accurately. Since human tower crews is a very complicated problem to be correctly represented by a model and perform accurate predictions on it (to be precise, this should be done by a MAS[7], and would not necessarily retrieve correct predictions). Therefore, it is necessary to use the information available to estimate the tendency of crews over time.

In this paper the criteria will be extracted as the average of the results during the previous n seasons. Let c be a criteria of the full criteria set C, a be an alternative of the full alternatives set A and s a season of the full seasons set S. Formally, then can be written that

$$\begin{gathered} \forall c_j \in C \quad \forall a \in A \quad \forall s \in S \\ c_j^s(a) = \frac{\sum_{i=1}^{n} (w_i r_j^{s-i}(a))}{n} \end{gathered} \tag{2}$$

, where $r_j^s(a)$ corresponds to the result recorded from alternative a during season s, with respect to criteria c_j, and w_i is a weight associated to the season from which the results where recorded. The w_i, when being different for each i value, corresponds to applying temporal smoothing.

Before going further let some *subcriteria* be defined.

Level of a crew:

Let a represent any crew of the alternatives set A, then the *level* of crew a in season s, is computed as the *row* of table 4 corresponding to the most valuable (i.e. more

7. multi-agent system

difficult) human tower, *unloaded* by the crew a within the season $s-1$. Formally, can be written as

$$level^s(a) = ROW(top - ht^{s-1}(a)) \tag{3}$$

, where $top - ht^s(a)$ is the most difficult human tower unloaded by the crew a during season s, and function $ROW(x)$ returns the row value associated to a human tower x in table 4.

The different criteria considered for this implementation were:

- **Growth index:**

  Measures the progression of the crew within the last three seasons, as an average of the increment in new more difficult constructions unloaded per season.

  Notice that this factor may be negative in some cases (e.g. when having the best performance of a certain season being lower rated, than the previous ones).

  Formally, the *Growth index* of any crew, a, of the total evaluated set, A, in the current season, s, is calculated as

$$\forall a \in A \qquad G(a)^s = \frac{level^{s-1}(a) - level^{s-3}(a)}{2} \tag{4}$$

- **Crew size:**

  The information of the crew size will be extracted from the human tower which requires more people (rather than the more difficult one) tried by the it within the last season. This criteria is categorical, the final value is not the human tower it self, but the group number where this human tower appears in table 4.

  Note: The human tower taken as reference, does not require to be achieved by the crew, since is just for measuring the size of this one.

- **Travelling time:**

  This criteria must be computed using information of the user profile. Time for arriving to the training building from the origin plus the time for going back home. Since human towers trainings tent to finish late in the evening, the weight assigned to the return travel will be twice the weight of the first travel. Formally, the travelling time for a user profile p, is calculated as

$$T(p, a) = \frac{2t(p.loc_1, a.loc) + 4t(a.loc, p.loc_2)}{3} \tag{5}$$

  , in this formula the following three *.loc* properties take part: $p.loc_1$ corresponds to the location from where the user has to go the training place, $a.loc$ the place where the crew usually trains, and $p.loc_2$ the one corresponding the return destination of the user. As can be observed the two times composing the total time are not directly added, but weighted previously. Notice that the unit has been maintained to be minutes, this decision was taken from the notion that the only manipulation on the original, rather than simply performing the standard *sum*, is performing a simple *weighted sum*. Thus, the units on the result could be maintained as in the original data.

- **Unsafeness index:**

  Calculated as a percentage of falls, with temporal smoothing, using the information of the current season and the two previous ones. Formally, the unsafeness index, U, of the ith crew in the season s is computed as

$$U_i^s = \frac{F_i^{s-3}}{6} + \frac{F_i^{s-2}}{3} + \frac{F_i^{s-1}}{2} \tag{6}$$

  , where F_i^t is the falling rate computed from the overall trials, which can be written as

$$F_i^t = \sum_{j=1}^{m} f(r_{ij}^t)$$
$$\forall r_{ij} \in R_i^t = \{r_{i1}, r_{i1}, ..., r_{im}\} \tag{7}$$

  , where $f(r_{ij}^t)$ is defined as

$$f(r_{ij}^t) = \begin{cases} 0 & \text{when } r \text{ did not fall,} \\ 2^l & \text{when } r \text{ did fall,} \end{cases} \tag{8}$$

  , being l the maximum of: 0; and the distance between the trial r_{ij} and the level of the evaluated crew in the evaluated season. Formally, l is defined as

$$l = max\{0, dist(r_{ij}, level(a_i))\} \tag{9}$$

  , recall that the *level* of the ith crew is computed as shown in equation (5.2).

  This distance is computed from table 4, where each each *row* between the two structures, e and f, will add +1 to the distance value of $dist(e, f)$. Notice that a crew falling from a human tower of a higher *row* position in the table, than their *level* (i.e. their maximum unloaded within that season, see (5.2)), can be severely penalised. This measure has been designed to punish crews trying to perform constructions without a progressive notion, and demonstrating that actually they were not well enough prepared for their quests (which, in fact, would lead them to success, not only omitting this penalisation, but increasing many other positive criteria).

  Next an example is exposed: A certain crew x has a level of 5 in season 2016 (row 5 corresponds to *3d7* in table 4, thus this is the most difficult construction unloaded in season 2015). Since they have this human tower "dominated" (i.e. unloaded several times), without training much, they intend to perform the *3d8* (which corresponds to row 17 in table 4). Their argument is that "you *physically* only need three people more and they have three substitute players that were able to take part in the *3d7* human tower". In this case, the penalisation when falling and not unloading this human tower within the same season, would be calculated as: 2^d, where $d = dist(3d8, 3d7) = 12$, so each fall from the *3d8* would be equivalent to falling 4096 times from the *3d7* (falling n times from the *3d7* would be calculated as $2^0 \times n$, while falling n times from the *3d8* is calculated as $2^1 2 \times n$).

This reasoning may seem exaggerated, but in fact, in this paper states it is considered that there is not sensible to consider the safeness of a crew which fell "apparently" intending to fall. As a crew, involving people, belonging to a crew, in unreasonable quests, will bring dramatic impacts to the unsafeness criteria calculation. Whereas, falling with low frequency from reasonable trials, will retrieve the best (minimal) results. Thus, failures should be reasonable regarding crews *level*.

- **Shirt color:**

  This criteria is by default categorical, however, the *ELECTRE III* is not able to deal with categorical data. Thus, this criteria will be represented as the set of colors belonging to the alternatives considered, each one represented by a numerical value, defining the position of this color within the ranking of colors generated, according to the user profile (i.e. possible colors are ranked in preorder in concordance with the evaluated profile).

  Although, this option will better fit the user desires, it should be noticed that usually will have scalability problems, when using the full set of alternatives. Therefore, alternative predefined rankings could be an interesting scalable solution (e.g. Hot vs Cold or Bright vs Dark color rankings).

- **Impressive events:**

  This criteria quantifies the amount of times that a crew has been at an event where there were "Gamma extra"[8] constructions performed. Notice that it is not taken into account if the constructions were actually built by the crew it self or by other participating crews in the event.

5.2.1. Criteria scales

In the previous sections the criteria were defined and described. However, there is still an fundamental aspect regarding the criteria, the *scale*, since the scale defines if a criteria is a positive or negative aspect of the alternatives set.

This paper considers two possible scales:

1. Maximize (MAX): The higher the better.

2. Minimize (MIN): The lower the better.

Although there are only considered two strategies for evaluating a certain criteria, some criteriaś scales might vary depending on the user profile, or even invert completely. In the case that a criteriaścale could be considered MAX or MIN, depending on the user profile, the correct term when describing the criteria scale will be *UD* (i.e. User Dependent).

Next the *scale* of each criteria is exposed and justified.

8. *Gamma extra* human towers are the ones considered more difficult than the *3d9f*, and occupy the last positions of the table 4, corresponding to the rows belonging to *GROUP 6* and *GROUP 7*.

- Growth index → MAX: As general *rule of thumb*[9], a crew which is in continuous growth, tends to be more positive and self confident. Therefore, for this paper it is assumed to have a higher growth index as a purely maximizing criteria.
- Crew size → UD: Regarding the crew size the following two possible cases are being considered:
    1. MAX: The user wants to get benefit from the larger crews characteristics (i.e. Large crews tend to be more famous, to perform more impressive constructions, to travel abroad often, etc.).
    2. MIN: The user wants to climb in the *top human towers*[10] performances of the crew, and as larger is the crew, the more competence and complicated becomes to be able to climb in any top human tower.
- Travelling time → MIN: It is assumed that the having lower travelling times will be positive for any user profile.
- Unsafeness index → MIN: It is assumed that the having lower unsafeness (i.e. more safeness) will be positive for any user profile.
- Shirt color → MIN: Since the colors will be previously sorted depending on the user profile preferences, in preorder. Thus, it is straight forward that as more in concordance is a the shirt color of a crew with the user preferences the better.
- Impressive events participation → MAX: Even if the user prefers being member of a small crew, being able to play where the most impressive constructions are performed is always positive.

5.2.2. Criteria summary

This section shows the relevant information concerning the algorithm proposed.

Table 1 illustrates the basic information on the the criteria being used for the RS.

Notes on table 1:

- The unit of the Growth index criteria is $\frac{\text{new ht}}{season}$, where *new ht* are the new more difficult human towers performed.
- The criteria without a specific standard unit associated have a "dash" (-) in the unit cell.
- The "UD" value in some scale cells, explains that the criteria might be "Maximized" or "Minimized" depending on the specific user profile, a more detailed explanation is provided in the criteria description in 5.2.1.

9. rule of thumb: is a principle with broad application that is not intended to be strictly accurate or reliable for every situation.
10. top human towers of a crew: most complicated human towers performed by the crew.

	ID	NAME	UNIT	SCALE
CRITERIA	Growth	Growth index	$\frac{\text{new ht}}{\textit{season}}$	MAX
	Size	Crew size	group (of the table 4)	UD
	Time	Travelling time	minutes	MIN
	Unsafeness	Unsafeness index	-	MIN
	Color	Shirt color	-	MIN
	Impressive	Impressive events participation	events	MAX

Table 1: Basic information of the criteria.

5.3. Alternatives considered

This paper considers only a subset of the total crews set. In order to simplify the problem and maintain a coherent and interesting set of alternatives, the crews chosen were Barcelona crews. Forming a set of six alternatives: *Castellers de Barcelona*, *Castellers de Sants*, *Castellers de la Vila de Gràcia*, *Castellers del Poble Sec*, *Castellers de la Sagrada Família* and *Colla Jove de Barcelona*.

5.3.1. Alternatives criteria values calculation

In this section the procedure for obtaining the criteria values of each crew is reviewed.

Notice that the alternatives are being evaluated regarding season $s = 2016$.

- **Castellers de Barcelona**
  - Growth index = 0.5 (new ht/s)

$$G_{cb}^{2016} = \frac{level_{cb}^{2015} - level_{cb}^{2013}}{2} = \frac{ROW(9d8) - ROW(3d9f)}{2} = \frac{28 - 27}{2} = 0.5$$

  - Crew size = 6

    The most difficult human tower unloaded was *9d8*.
  - Travelling time = *depends on the user profile.*
  - Unsafeness index = 183.67

$$\begin{aligned} U_{cb}^{2016} &= \frac{F_{cb}^{2013}}{6} + \frac{F_{cb}^{2014}}{3} + \frac{F_{cb}^{2015}}{2} = \frac{14(2^0)}{6} + \frac{14(2^0) + 1(2^9)}{3} + \frac{12(2^0)}{2} \\ &= \frac{14}{6} + \frac{14 + 512)}{3} + \frac{12}{2} = \frac{14 + 1052 + 36}{6} = 183.67 \end{aligned}$$

, notice that this crew had a fall in season *2014* from a *4d9sf*, which corresponds to row *37* in table 4, having at during the same season unloaded the *9d8*, which corresponds to row *28*, as most challenging construction, therefore the distance between both constructions, *9*, is places as the exponent in the formula.

  - Shirt color = red.
  - Impressive event participation = 4 (events).
  - Training location: *Carrer de Bilbao, 212, 08018 Barcelona, Espanya.*

    The training location is not a criteria it self, but a subcriteria used for the calculation of the *Travelling time* criteria. In fact, corresponds to the *a.loc* in equation (5.2).

- **Castellers de Sants**
  - Growth index = 1.5 (new ht/s)

$$G_{cs}^{2016} = \frac{level_{cs}^{2015} - level_{cs}^{2013}}{2} = \frac{ROW(2d9fm) - ROW(3d9f)}{2} = \frac{30 - 27}{2} = 1.5$$

  - Crew size = 6

    The most difficult human tower unloaded was *2d9fm*.
  - Travelling time: *depends on the user profile.*
  - Unsafeness index = 6.17

$$\begin{aligned} U_{cs}^{2016} &= \frac{F_{cs}^{2013}}{6} + \frac{F_{cs}^{2014}}{3} + \frac{F_{cs}^{2015}}{2} = \frac{3(2^0)}{6} + \frac{3(2^0) + 1(2^1)}{3} + \frac{8(2^0)}{2} \\ &= \frac{3}{6} + \frac{3+2}{3} + \frac{8}{2} = \frac{3 + 10 + 24}{6} = 6.17 \end{aligned}$$

, notice that this crew had a fall in season *2014* from a *pd8fm*, which corresponds to row *31* in table 4, having at during the same season unloaded the *2d9fm*, which corresponds to row *30*, as most challenging construction, therefore the distance between both constructions, *1*, is places as the exponent in the formula.

  - Shirt color = grey.
  - Impressive event participation = 7 (events).
  - Training location: *Escola Jaume I. Comtes de Bell-lloc, 86, 08014 Barcelona.*

    The training location is not a criteria it self, but a subcriteria used for the calculation of the *Travelling time* criteria. In fact, corresponds to the *a.loc* in equation (5.2).

- **Castellers de la Vila de Gràcia**
  - Growth index = 0 (new ht/s)

$$G_{cg}^{2016} = \frac{level_{cg}^{2015} - level_{cg}^{2013}}{2} = \frac{ROW(3d9f) - ROW(3d9f)}{2} = \frac{27 - 27}{2} = 0$$

- Crew size = 5

  The most difficult human tower unloaded was *3d9f*.
- Travelling time: *depends on the user profile.*
- Unsafeness index = 6.5

$$U_{cg}^{2016} = \frac{F_{cg}^{2013}}{6} + \frac{F_{cg}^{2014}}{3} + \frac{F_{cg}^{2015}}{2} = \frac{5(2^0)}{6} + \frac{8(2^0)}{3} + \frac{6(2^0)}{2} = 6.5$$

- Shirt color = blue.
- Impressive event participation = 3 (events).
- Training location: *Carrer de Alzina número 7, Barcelona.*

  The training location is not a criteria it self, but a subcriteria used for the calculation of the *Travelling time* criteria. In fact, corresponds to the *a.loc* in equation (5.2).

- **Castellers del Poble Sec**
  - Growth index = 0 (new ht/s)

$$G_{cp}^{2016} = \frac{level_{cp}^{2015} - level_{cp}^{2013}}{2} = \frac{ROW(4d8) - ROW(4d8)}{2} = \frac{15 - 15}{2} = 0$$

  - Crew size = 3

    The most difficult human tower unloaded was *4d8*.
  - Travelling time: *depends on the user profile.*
  - Unsafeness index = 4.5

$$U_{cp}^{2016} = \frac{F_{cp}^{2013}}{6} + \frac{F_{cp}^{2014}}{3} + \frac{F_{cp}^{2015}}{2} = \frac{5(2^0)}{6} + \frac{5(2^0)}{3} + \frac{4(2^0)}{2} = 4.5$$

  - Shirt color = light blue.
  - Impressive event participation = 1 (events).
  - Training location: *Carrer Blesa, 7, 08004, Barcelona.*

    The training location is not a criteria it self, but a subcriteria used for the calculation of the *Travelling time* criteria. In fact, corresponds to the *a.loc* in equation (5.2).

- **Castellers de la Sagrada Família**
  - Growth index = 1.5 (new ht/s)

$$G_{cf}^{2016} = \frac{level_{cf}^{2015} - level_{cf}^{2013}}{2} = \frac{ROW(4d8) - ROW(3d7s)}{2} = \frac{15 - 12}{2} = 1.5$$

- Crew size = 3

  The most difficult human tower unloaded was *4d8*.
- Travelling time: *depends on the user profile*.
- Unsafeness index = 3.33

$$U_{cf}^{2016} = \frac{F_{cf}^{2013}}{6} + \frac{F_{cf}^{2014}}{3} + \frac{F_{cf}^{2015}}{2} = \frac{2(2^0) + 1(2^3)}{6} + \frac{2(2^0)}{3} + \frac{2(2^0)}{2} = 3.33$$

  , notice that this crew had a fall in season *2013* from a *4d8*, which corresponds to row *15* in table 4, having at during the same season unloaded the *3d7s*, which corresponds to row *12*, as most challenging construction, therefore the distance between both constructions, *3*, is places as the exponent in the formula.
- Shirt color = pale green.
- Impressive event participation = 0 (events).
- Training location: *Passatge de Sant Pau, 16, 08025, Barcelona.*

  The training location is not a criteria it self, but a subcriteria used for the calculation of the *Travelling time* criteria. In fact, corresponds to the *a.loc* in equation (5.2).

- **Colla Jove de Barcelona**
  - Growth index = 0 (new ht/s)

$$G_{cj}^{2016} = \frac{level_{cj}^{2015} - level_{cj}^{2013}}{2} = \frac{ROW(5d7) - ROW(5d7)}{2} = \frac{9-9}{2} = 0$$

  - Crew size = 2

    The most difficult human tower unloaded was *5d7*.
  - Travelling time: *depends on the user profile*.
  - Unsafeness index = 1.17

$$U_{cj}^{2016} = \frac{F_{cj}^{2013}}{6} + \frac{F_{cj}^{2014}}{3} + \frac{F_{cj}^{2015}}{2} = \frac{2(2^0)}{6} + \frac{1(2^0)}{3} + \frac{1(2^0)}{2} = 1.17$$

  - Shirt color = maroon.
  - Impressive event participation = 0 (events).
  - Training location: *Fabra i Coats, C Sant Adrià, 20, sant Andreu, Barcelona.*

    The training location is not a criteria it self, but a subcriteria used for the calculation of the *Travelling time* criteria. In fact, corresponds to the *a.loc* in equation (5.2).

5.3.2. Alternatives criteria summary

The following table illustrates the performance evaluation of each crew, regarding the previously mentioned criteria in section 5.2.

ALTERNATIVES \ CRITERIA	Growth	Size	Time	Unsafeness	Color	Impressive
Castellers de Barcelona	0.5	6	-	183.67	red	4
Castellers de Sants	1.5	6	-	6.17	grey	7
Castellers de la Vila de Gràcia	0	5	-	6.5	blue	3
Castellers del Poble Sec	0	3	-	4.5	light blue	1
Castellers de la Sagrada Família	1.5	3	-	3.33	pale green	0
Colla Jove de Barcelona	0	2	-	1.17	maroon	0

Table 2: Alternatives performance evaluation.

In table 2 the performance of all criteria for each alternative can be observed. However, notice that the *Travelling time* criteria is missing in the table. This is due the fact that, *Travelling time* calculation is user profile dependent (i.e. the formula for calculation the time requires complementary information extracted from the user profile).

5.4. The RS algorithm

For selecting the algorithm that best fitted the proposed features, a set of different algorithms were chosen as candidates and grouped by common features, next a hierarchical decision process was performed. The full selection process is discussed in this section.

Note: Although this paper only considers a subset of the total existing human tower crews. Its intention is to provide with a possible feasible RS, for the full set of alternatives, which currently are 71 existing crews around the world.

Next the hierarchical decision process is reported:

1. **MAUT or Outranking**
   - Multi-attribute utility theory (MAUT)
     Aggregation Approaches
     - Traditional utility aggregation methods, such as weighted average over the utilities computed for each criteria.
       Although, this might seem the most simple to implement algorithm, it is very complicated to define correctly all the weights in a generalised way, avoiding having undesirable offset situations.

  - OWA[11] (Yager, 1988) operators follow an aggregation technique based on the ordered weighted averaging operators. OWA gives weights to the performance values instead of criteria. It permits to define aggregation policies such *AND*[12] and *OR*[13]. Although, lacks from the capacity of evaluating the alternative in a criteria wise notion. Whereas, other aggregation methods also permit to define the *AND* and *OR* strategies, but maintaining the criteria distinction possibility.
    Despite of the simplicity of the OWA methods, notice that are usually focused on dealing with fuzzy criteria sets. Moreover, as has been stated, their best performance is reached when there is non strong preference between criteria. Thus, this alternative could not solve the problem properly with the current specification.
  - UTA[14] (Jacquet-Lagreze und Siskos, 1982) methods are to infer additive marginal utility functions through a set of preferences given by the DM[15], under the assumptions of the axiomatic basis of MAUT[16] (Keeney und Raiffa, 1976) and adopting the preference disaggregation principle.
    Although this set of alternatives is very interesting, notice that for performing the regression and inferring the preference relations among criteria, the algorithm requires, at least, pairwise comparisons among alternatives (e.g. in UTA^{GMS}(Greco u. a., 2008) and GRIPFigueira u. a. (2009)).

- Outranking
  Selection methods
  - ELECTRE[17] I(Roy, 1968) uses a graph from the credibility matrix, represents relations over certain threshold. Retrieves kernels (i.e. subsets of alternatives) as possible solutions for the problem.
    Although this method is more simple than the rest of outranking methods reviewed in this paper, it must be noticed that it lacks from retrieving a unique and robust candidate. Since its output is constituted usually by a subset of alternatives.

  Ranking methods
  - ELECTRE II(Roy, 1971) uses the NFS[18] strategy, which measures the number of alternatives that are strongly outranked by each alternative and subtracts the number of alternatives that strongly outrank this alternative, for a certain threshold of credibility. In order to calculate a final value which is used to rank the alternatives.
    Although this method would retrieve a ranking among the alternatives evaluated, which fulfils the requirements of the RS. It is well known that *NFS*

11. OWA: Ordered weighted averaging.
12. AND → all criteria must be satisfied.
13. OR → at least one criteria must be satisfied.
14. UTA: UTilité Additive.
15. DM: Decision Maker
16. MAUT: Multi-Attribute Utility Theory
17. Elimination Et Choix Traduisant la RÉalité
18. Net Flow Scores

has undesirable properties in its results (e.g. it is likely to rank options as better alternatives than others which explicitly outrank them).

- ELECTRE III(Roy, 1978) uses the *distillation* strategy in the exploitation step. Creates two complete preorderings, ascending and descending preorderings, and from the intersection of them the final global preference is drawn.

  Although this method is known to still carries some of the problems inherited from ELECTRE II, it is also an improvement of this one. Thus, when willing to use a ranking algorithm, this would be preferred option so far.

Sorting methods

- ELECTRE TRI(Yu, 1992) assigns alternatives to a set of known and ordered categories. Alternatives must be independent. Categories are characterised by an upper and lower bounds, which serve as upper bound of a class and the lower bound of the next class. Considering the boundaries as possible alternatives, performs pairwise comparisons in order to place each alternative in the most adequate gap.

  Requires defining categories within the hypothetical alternatives space. This might imply even more parameters than ELECTRE III. Moreover, the complexity relies in that the user must have strong knowledge on the problem domain in order to correctly define the categories, and this ones are critical for obtaining useful results.

All ELECTRE methods have the weakness of requiring many parameters to be defined using information of the user profile. However, compared to having to define utility functions (i.e. traditional aggregation methods) or pairwise comparisons among the full set of alternatives in order to infer the utilities (e.g. UTA based methods), for each user profile. Is not considered as an unsalable option in this paper.

As can be observed the outranking algorithms considered in this paper, are a subset of the ELECTRE methods, which, together with the PROMETHEE (see Brans, 1982) family of methods, actually constitute the most popular outranking algorithms in the reviewed literature.

2. **Discarding alternatives**

   From the descriptions and observations on the possible candidate algorithms for the RS and recalling that the assumption of disposing of pairwise preference relations among random alternatives of the alternative set for each user profile, is not sensible. Since, the system is aimed to support users who are willing to join a crew, without regarding their domain knowledge. It is easy to notice that the most reasonable options would be: ELECTRE II, ELECTRE III and ELECRE TRI. Knowing that ELECTRE III generalises ELECTRE II, solving the many incomparability alternatives problem which are usually driven by ELECTRE II, the remaining candidates would be ELECTRE III and ELECTRE TRI.

3. ELECTRE III or ELECTRE TRI

- **Arguments in favour of ELECTRE III**
  - Retrieves a complete ranking on the alternatives evaluated, thus the RS is usually able to retrieve one (or at least a small subset) of alternatives as preferred options.
  - Does not require to define boundaries, neither categories on the alternatives space.
  - Requires less assumptions in general, and less domain knowledge from the user on the problem characteristics.
- **Arguments in favour of ELECTRE TRI**
  - Is more easy to interpret the results.
  - Avoids the problems driven by the distillation process of having explicit information contradicted in the final result.

4. Finally the chose algorithm for solving the RS problem was the ELECTRE III(see Roy, 1978), since in this paper it is considered to generalise better, since it requires less assumptions on the user profile.

6. Testing the RS designed

This section presents, and discusses, the tests proposed for the RS designed.

6.1. ELECTRE III parameters

Regarding the parameters required for the ELECTRE III distillation, the configuration chose was the following:

- $\alpha = -0.05$
- $\beta = 0.1$

, where these parameters determine the *cut* change in the distillation equation, as

$$cut_k = cut_{k-1} - (\alpha cut_{k-1} + \beta) \tag{10}$$

, where it can be observed that the *cut* in the kth iteration, cut_k, is being calculated with respect to the *cut* calculated in the previous iteration, cut_{k-1}, minus the second part of the equation, $(\alpha cut_{k-1} + \beta)$, which depends on α and β. The specific configuration chosen for the mentioned set of parameters, is reviewed to be a standard configuration, since the most important characteristic is that the cuts are small enough to be representative. In the software diviz, the default configuration set both parameters to larger, in absolute value, values. Therefore, it can be supported that the configuration chose is correct. It is also the configuration reviewed in one of the practical exercises of MCDSS[19]

19. Multi-criteria decision support systems subject of the master in artificial intelligence, in *Universitat Rovira i Virgili* documentation.

6.2. User profile for testing

In order to perform the tests on the RS designed, a user profile was required. Thus, it was necessary to define the required information of a fictitious possible user, which is used for testing the RS for acquiring support recommendations in concordance to the profile defined.

For the experiments and tests of this paper let as assume the existence of a user profile, p, with the following information:

- The growth of the crew is very important, in fact is a *must*.
- Prefers being in a larger crew, but it is not as important as the safeness property.
- The travelling time is important, but not within ten minutes over the total counting. However, twenty minutes of difference is preferred, whereas half an hour (i.e. thirty minutes) is stated as too much difference.
- Is concerned about crews safety, in fact this is a *must* requirement.
- The shirt color preferences are:
  1. blue
  2. pale green
  3. red
  4. light blue
  5. maroon
  6. grey

  , in descending order (i.e. from best to worst alternative). Although, this factor being very important, since there will be records of the events, it is not a *must* requirement.
- Being in impressive events is not very important, since for starting most events will seem impressive.
- Origin location → *Carrer del Torrent de l'Olla, 130-132, 08012 Barcelona.*
- Destination location → *Carrer del Torrent de l'Olla, 130-132, 08012 Barcelona.*

The origin location corresponds to the user profile $p.loc_1$ in equation (5.2), while the destination location corresponds to $p.loc_2$ in the same equation (5.2). In this specific case, both locations related to the user are the same one, since it is supposed that it will return home before going to the training. However, the cases of working nearby the training place and living far from it, or viceversa, are contemplated, moreover, they are evaluated differently, as it can be seen in equation (5.2).

From the new information regarding the user shirt color preferences 6.2 and profile locations (i.e. $p.loc_1$ and $p.loc_2$). The information among the value corresponding to the *Shirt color* and *Travelling time* performances of the alternatives evaluated, shown in table 2, can be finally calculated, by applying the defined methods in section 5.2.

***Travelling times* and *Shirt color* performances**

- Castellers de Barcelona
  - Shirt color = 3
  - Travelling time = 62 min
- Castellers de Sants
  - Shirt color = 6
  - Travelling time = 52 min
- Castellers de la Vila de Gràcia
  - Shirt color = 1
  - Travelling time = 14 min
- Castellers del Poble Sec
  - Shirt color = 4
  - Travelling time = 56 min
- Castellers de la Sagrada Família
  - Shirt color = 2
  - Travelling time = 52 min
- Colla Jove de Barcelona
  - Shirt color = 5
  - Travelling time = 64 min

In order to obtain the times performances this paper uses googlemaps web application, for obtaining the evaluation of the $t(x)$ function in equation (5.2).

6.3. Test configurations

From the above specification of the "hypothetical" user profile, in this paper the following specific configurations of the ELECTRE parameters are considered.

CONFIGURATIONS		Criteria	SCALE	IND	PREF	VETO	WEIGHT
			PARAMETERS				
	CONF 1	Growth	MAX	0	1	3	0.25
		Size	MAX	1	2	-	0.10
		Time	MIN	10	20	30	0.20
		Unsafeness	MIN	2	5	10	0.15
		Color	MAX	0	2	-	0.25
		Impressive	MAX	3	5	-	0.05
	CONF 2	Growth	MAX	0	1	3	0.25
		Size	MAX	1	2	-	0.10
		Time	MIN	10	20	30	0.20
		Unsafeness	MIN	2	5	-	0.15
		Color	MAX	0	2	-	0.25
		Impressive	MAX	3	5	-	0.05
	CONF 3	Growth	MAX	0	1	-	0.25
		Size	MAX	1	2	-	0.10
		Time	MIN	10	20	-	0.20
		Unsafeness	MIN	2	5	-	0.15
		Color	MAX	0	2	-	0.25
		Impressive	MAX	3	5	-	0.05

Table 3: Configurations of the ELECTRE credibility matrix parameters, related to the designed profile for testing purposes.

In the following section 7 the results obtained from the experiments performed with the configurations exposed, in 3, are discussed.

7. Discussion on the results

In this section the results obtained during the testing phase for this paper, are reported and discussed.

7.1. Test 1: original configuration

In this section the results obtained from the experiments when using configuration *CONF 1*, shown in table 3, are exposed and discussed.

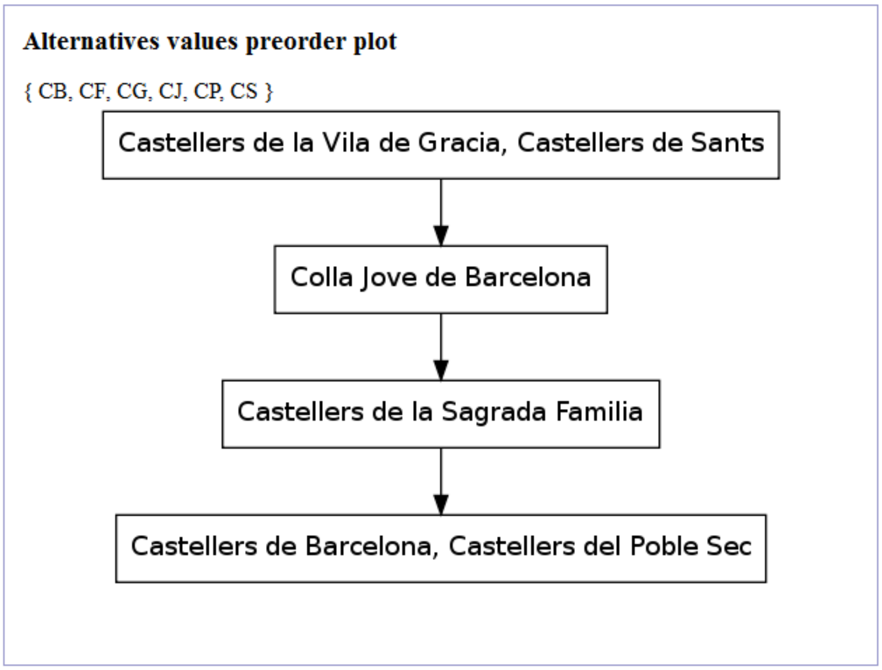

Figure 2: Ranking retrieved by *ELECTRE III*, with configuration *CONF 1*.

Figure 2 presents the results that the RS would retrieve to a user with the defined profile in this paper. It is interesting to notice that although *Castellers de Barcelona* alternative has higher performance in most of criteria than other alternatives (e.g. when compared to *Castellers del Poble Sec*, it can be observed that all criteria is significantly higher, except for the *Travelling time*, which is indifferent, and the *Unsafeness index*, which is outranked), it is never able to outrank any of them, since the *veto* on *Unsafeness index* criteria is excluding this alternative from the full procedure, due to its dramatic high value in the criteria, when having to be minimised.

A deeper insight view on the results retrieved by *ELECTRE III* method (e.g. the distillation intersection results supporting the commented situation regarding the *Castellers de Barcelona* alternative), can be found in the Appendix B, in section B.1.

7.2. Test 2: relaxed safeness constraint

In this section the results obtained from the experiments when using configuration *CONF 2*, shown in table 3, are exposed and discussed.

As was commented in 7.1, the *veto* among *Unsafeness index* criteria, had completely excluded the *Castellers de Barcelona* from the procedure. Although, the algorithm had retrieved a correct rank regarding the profile defined. This paper proposes two additional tests, performed among the same configurations, with some slightly changes in the *veto* parameters.

The configuration proposed for the second test (*CONF 2* in table 3), removes the *veto* from the *Unsafeness index* criteria, in order to observe the influence of this concrete *veto* threshold over the full outranking procedure.

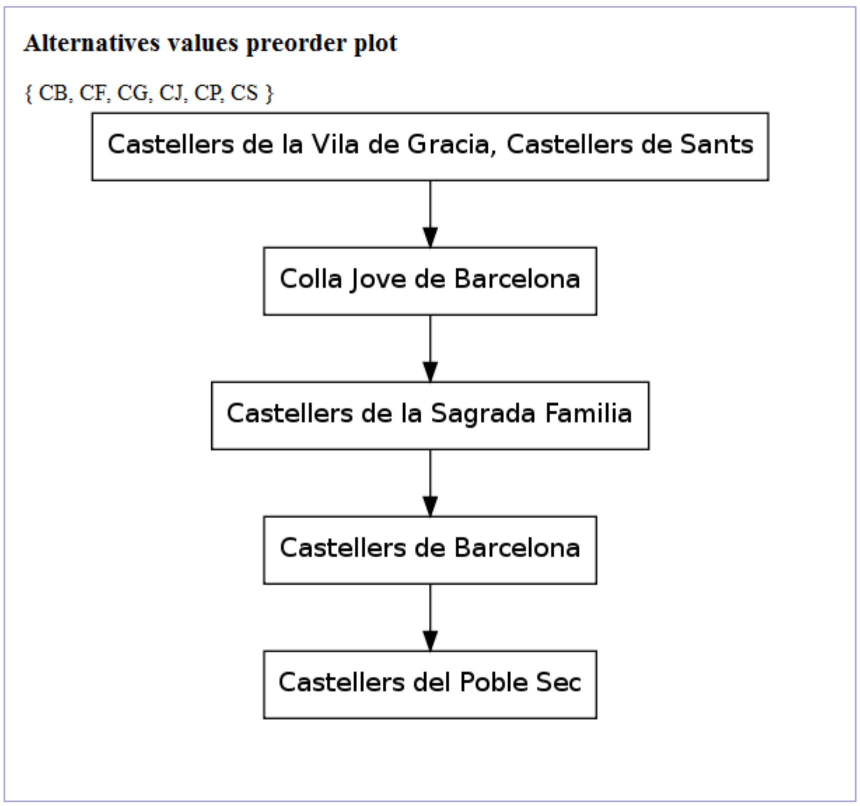

Figure 3: Ranking retrieved by *ELECTRE III*, with configuration *CONF 2*.

Figure 2 presents the results that ELECTRE III retrieves when omitting the *veto* threshold for *Unsafeness index* criteria. As was commented in section 7.1, the *Castellers de Barcelona* was then ranked as a better alternative than *Castellers del Poble Sec*. However, the global situation did not change much. Therefore, the initial assumption of being the *veto* threshold on the *Unsafeness index* criteria, being the main reason for having *Castellers de Barcelona* ranked as the less recommendable options, was discarded. Since, in the rank drawn in 2, illustrates almost the same results than the ones retrieved with the original 2.

7.3. Test 3: without veto

In this section the results obtained from the experiments when using configuration *CONF 3*, shown in table 3, are exposed and discussed.

Finally, the third configuration was designed with the purpose of viewing the overall effect of the *veto* thresholds set in the original and the relaxed safeness constraint configurations, corresponding to *CONF 1* and *CONF 2* in table 3 respectively.

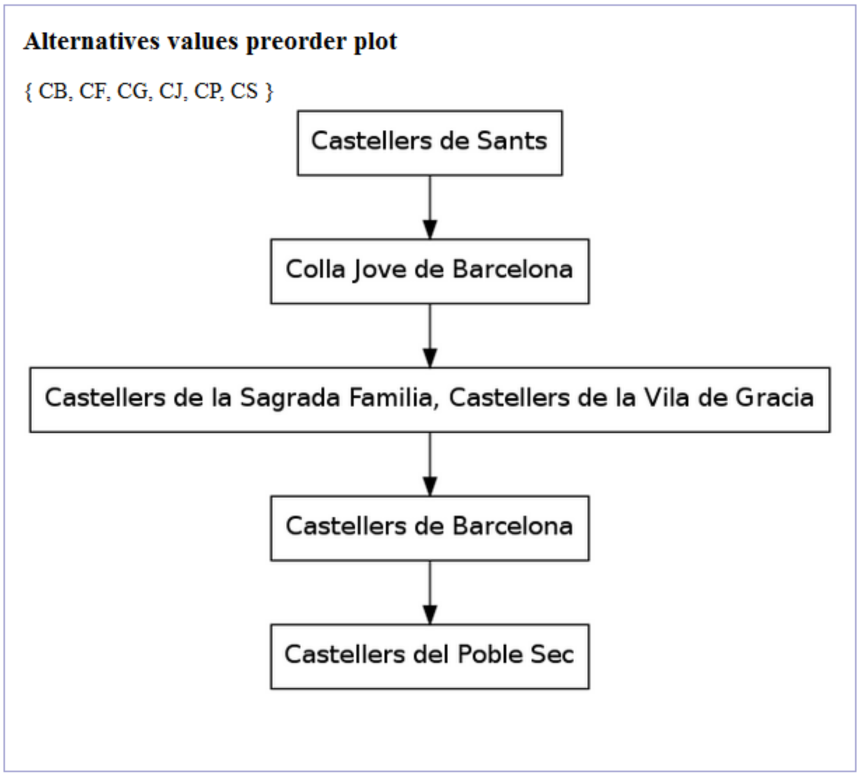

Figure 4: Ranking retrieved by *ELECTRE III*, with configuration *CONF 3*.

In figure 4 the ranking of alternatives without *veto* thresholds is shown. It can be observed that the only alternative which move position when changing the configurations are *Castellers de Barcelona* and *Castellers de la Vila de Gràcia*, while other alternatives maintain their rank positions no matter what (within the tests performed).

8. Extensions, strengths and weaknesses

This section presents the evaluation conclusions on the performance analysis, of this project.

8.1. Extensions

Due the time limitation resources it was not possible to implement the algorithms selected as sensible candidates, or to explore further interesting methods, such as PROMETHEE (see Brans, 1982).

Some other possible extensions for this project would be:

- Using the full set of crews as the set of alternatives, for evaluation and testing of the proposed RS method.
- Using real user profiles candidates for the testing experiments. Gathered from interviews or surveys, in order to give the testing settings more importance within the experiments developed. Would be useful for comparing how different algorithms match differently the user preferences, and comparing them with respect to a hand crafted ranking performed with the users indications.
- Using prediction models for inferring the future of a crew in global terms, instead of just performing temporal smoothing for defining most of criteria.

8.2. Strengths

MCDA and "Castells" are trendy concepts, moreover, when related to RS, which are also an interesting area. The paper gives a clear and brief insight about the most important elements in the MCDA design process, focusing on the specific scenario of the human towers crews. While giving a general global view on the ELECTRE III method.

Other strengths of this project would be:

- The target scenario proposed is in an very interesting stage of its history, which commonly is named the "Time of platinum", referring to the most amazing period until now. Moreover, the topic is related to the local culture, where the project is being carried.
- All the information used and presented in this paper is real information, extracted from a handcrafted historical dataset of the human tower crews performances over the last five years. The problem and the data where not academically designed, but searched and reviewed. Therefore, the problem was solved on the real field and its solution, could be extended as a working application for real users, willing to join a crew.

8.3. Weaknesses

During the development of this project some problems appeared, forcing changing the initial planing, to the finally presented in this paper. The two most relevant issues during this work were:

- The impressive amount of definitions required for giving to the project the robustness and support necessary for presenting it as a serious report, on a real study case using real data.
- The lack of previous work regarding the modelling of the human towers crews, at any level. Forcing the complete and exhaustive description and justification of every single step within the process of defining the model as it has been defined, together with all its characteristics, limitations and simplifications. Also, all the evaluations on the parameters had to be designed from scratch.
- The previous two points, leaded to an unavoidable overload of work, which precluded the possibility of programing the criteria extraction from the dataset, in order to obtain automatically representation of the full set of alternatives (i.e. the existing 71 human towers crews around the world).
- There did not exists any complete historical record of the human towers crews activity, of easy access. In fact, it was necessary to perform more than one hundred queries to obtain the data composing the used dataset.
- Much information was not even public. Such as crews number of members insured, which would have permitted representing more accurately the *Crews size* criteria; or cost per year of the insurance per each crew, which would allowed a more precise representation of the severity of falls suffered by crews, thus, building a more robust *Unsafeness index* criteria, by weighting the falls depending on the bill of the hospital (if any).

9. Concluding Remarks

This paper presents a RS, for solving the problem of recommending human towers crews, by generating a rank over the set of human tower crews evaluated, given a user profile specification.

The selected algorithm for performing the raking was ELECTRE III, which is a method from the *outranking methods family*. The outranking methods are aimed in raking alternatives, without specifying the *degree* of the relations among alternatives.

9.1. Future work

As has been commented in section 8.1, there exist many improvements which could be performed in order to continue this project. However, it would be perhaps more reasonable to test the current design before going further, in order to detect functional weaknesses on the model presented.

It has already been noticed that the *Unsafeness index* regulation, is actually perhaps to strict, although it has a sensible measurement strategy. A better approach to this problem, would be finding an alternative calculation which better reflects the danger index of a certain crew, when compared to the rest, but without retrieving dramatic results when there was a non sensitive isolated action.

Performing further exploration on the possible interesting properties that could be represented as part of the criteria, using additional information sources, such as social media content (e.g. *friends* opinions of crews, ideologies of users and crews matching, average displacement for playing, usual events where it takes part, such as participation in the *Concurs*ConcursCastells, etc.).

9.2. Conclusions

In order to design properly the RS, this paper presents a deep research on the related review on the literature surrounding the *Castells* topic was performed. Thus, after this work a strong understanding about how to search data for designing a RS, with all the sub-designs required (i.e. scenario definition, criteria design, criteria evaluation for a RS, testing, etc.).

This paper also presents a practical application case of the ELECTRE III method, for solving a multicriteria RS on a real problem.

Related literature has been reviewed showing that a lot of work is being done with this methods, but still there is a lot to explore.

The research performed regarding the multicriteria RS leaded too some main conclusions:

1. For solving properly a multicriteria problems, a strong description on the domain is required.

2. Although the data exists, not much work has been done within the local topics. In fact, the datasets do not exist by them selves, difficulting the access and usage to data. Which could held to mutual benefits, by creating applications and promoting the local culture.

3. Big-data is leading to changes in the modelling paradigm, since there is too much data to be able to model it traditionally. Which, in any case, would lead to an overfitted model.

4. Several research is being done on the same line of the principles presented by Roy (1968). However, it seams not to be the most popular techniques applied to the RS currently, this area is mainly predominated by ML[20] and MAS research groups.

20. Machine learning.

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Appendix A. Table of Points in 2016

ROW	GROUP	SUBGROUP	HUMAN TOWER	LOADED POINTS	UNLOADED POINTS
1	GROUP 0	sub 1	2 de 6	120	140
2			p de 5	135	155
3	GROUP 1	sub 1	9 de 6	165	190
4			4 de 7	175	200
5			3 de 7	185	210
6	GROUP 2	sub 1	3 de 7 a	240	265
7			4 de 7 a	250	275
8		sub 2	7 de 7	250	290
9			5 de 7	265	305
10		sub 3	7 de 7 a	300	320
11			5 de 7 a	310	330
12			3 de 7 s	315	335
13	GROUP 3	sub 1	9 de 7	365	420
14			2 de 7	385	440
15			4 de 8	400	460
16		sub 2	P de 6	425	485
17			3 de 8	445	510
18	GROUP 4	sub 1	7 de 8	550	635
19			2 de 8 f	580	665
20			P de 7 f	610	695
21		sub 2	5 de 8	640	735
22			4 de 8 a	700	770
23			3 de 8 a	730	805
24			7 de 8 a	740	815
25		sub 3	5 de 8 a	765	845
26	GROUP 5	sub 1	4 de 9 f	920	1055
27			3 de 9 f	965	1110
28	GROUP 6	sub 1	9 de 8	1210	1390
29		sub 2	3 de 8 s	1325	1460
30			2 de 9 fm	1330	1530
31			P de 8 fm	1395	1605
32		sub 3	7 de 9 f	1465	1685
33			5 de 9 f	1515	1740
34			4 de 9 fa	1630	1800
35			3 de 9 fa	1680	1855
36		sub 4	5 de 9 fa	1765	1945
37	GROUP 7	sub 1	4 de 9 sf	2015	2315
38			2 de 8 sf	2080	2395
39			3 de 10 fm	2130	2450
40			9 de 9 f	2130	2450
41			4 de 10 fm	2215	2550
42		sub 2	2 de 9 sm	2330	2675
43		sub 3	P de 9 fmp	2445	2810
44			3 de 9 sf	2565	2950

Table 4: Points table for the 26th edition of the "Concurs de Castells"(PointsTable).

Table 4 shows the official evaluation metrics for the human towers decided for the 2016 "Concurs", which will be the evaluation metrics used during this project.

Appendix B. Additional results from the testing

The aim of this section is providing the partial results retrieved during the outranking method executions, in order to support the results discussed in this paper.

Thus, this section includes additional information retrieved from the experiments, which was used internally for computing the final rankings shown in section 6.

B.1. Additional results for: Test 1

This section presents complementary results to the ones exposed in 7.1.

The configuration used for this experiment was *CONF 1* (see table 3).

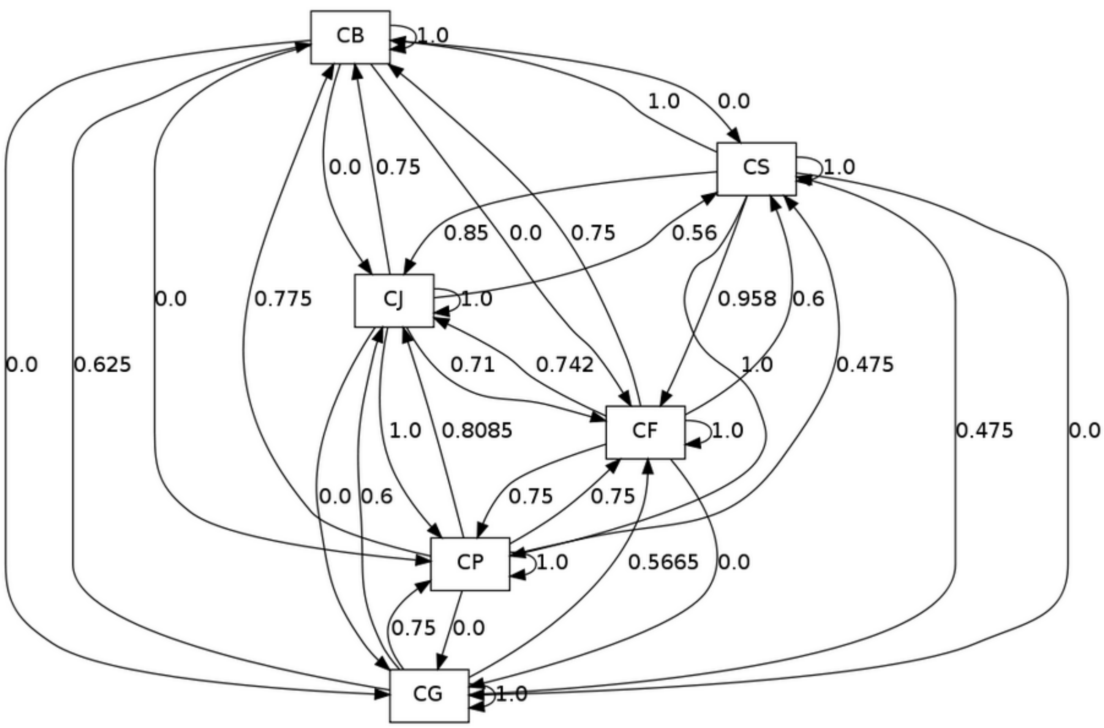

Figure 5: Credibility relations graph, leading to results in 7.1.

Alternatives values

CB	5
CF	4
CG	3
CJ	2
CP	4
CS	1

Figure 6: Downwards distillation ranking, leading results in 7.1.

Alternatives values

CB	5
CF	4
CG	1
CJ	3
CP	6
CS	2

Figure 7: Upwards distillation ranking, leading results in 7.1.

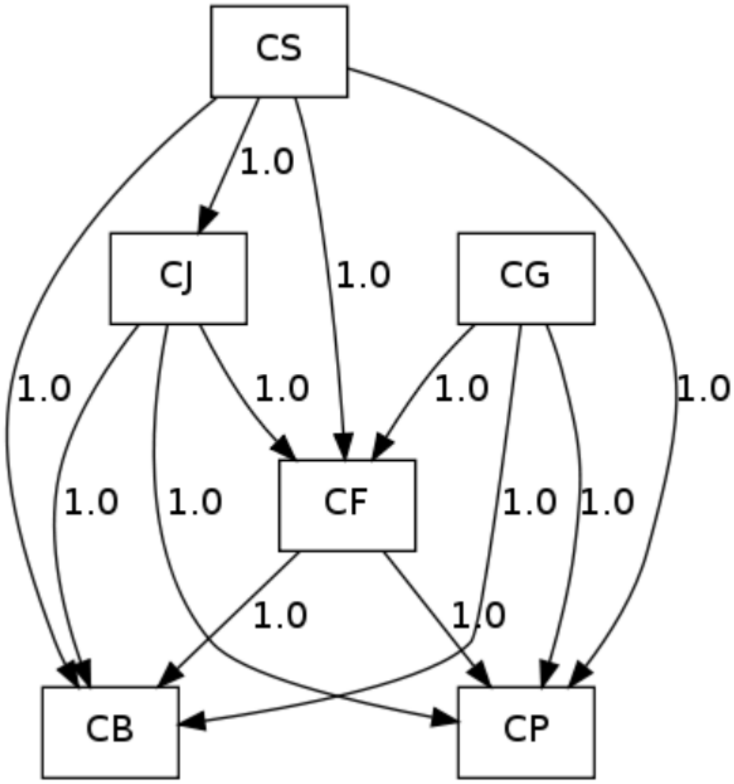

Figure 8: Intersection distillation graph, leading results in 7.1.

Alternatives values

CB	4
CF	3
CG	1
CJ	2
CP	4
CS	1

Figure 9: Final rank, which represents the same information than figure 2 in 7.1.

B.2. Additional results for: Test 2

This section presents complementary results to the ones exposed in 7.2.

The configuration used for this experiment was *CONF 2* (see table 3).

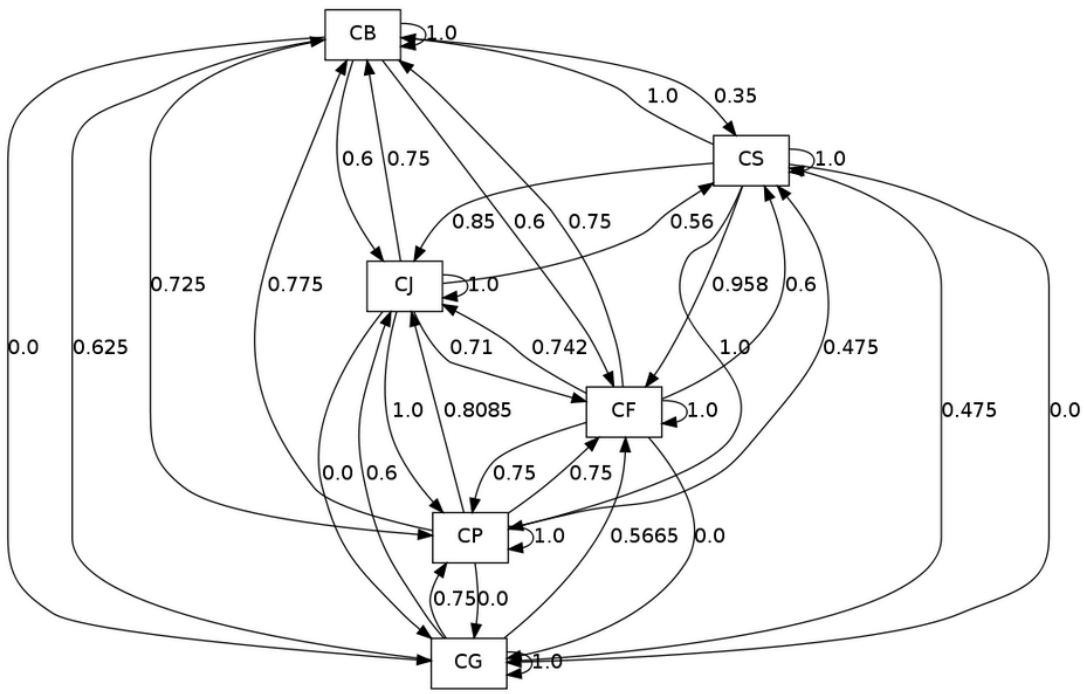

Figure 10: Credibility relations graph, leading results in 7.1.

Alternatives values

CB	5
CF	4
CG	3
CJ	2
CP	5
CS	1

Figure 11: Downwards distillation ranking, leading results in 7.2.

Alternatives values

CB	5
CF	4
CG	1
CJ	3
CP	6
CS	2

Figure 12: Upwards distillation ranking, leading results in 7.2.

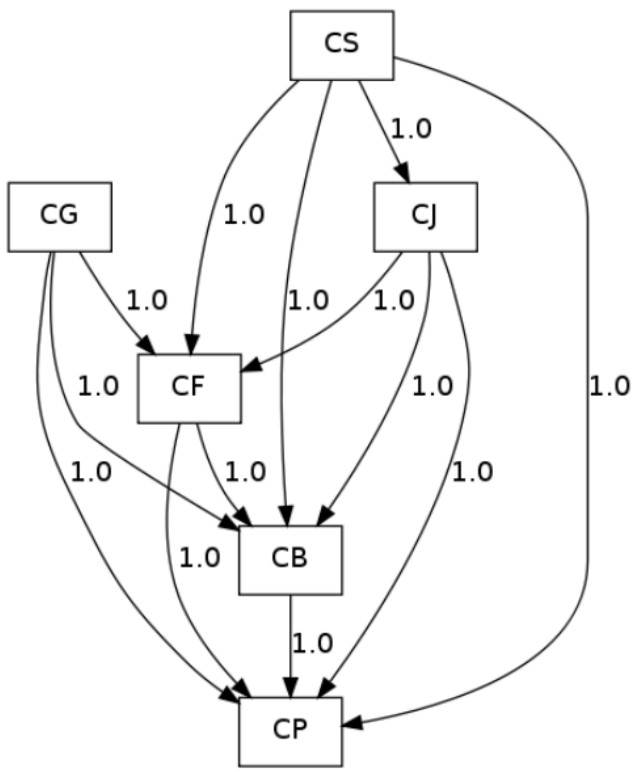

Figure 13: Intersection distillation graph, leading results in 7.2.

Alternatives values

CB	4
CF	3
CG	1
CJ	2
CP	5
CS	1

Figure 14: Final rank, which represents the same information than figure 3 in 7.2.

B.3. Additional results for: Test 3

This section presents complementary results to the ones exposed in 7.3.

The configuration used for this experiment was *CONF 3* (see table 3).

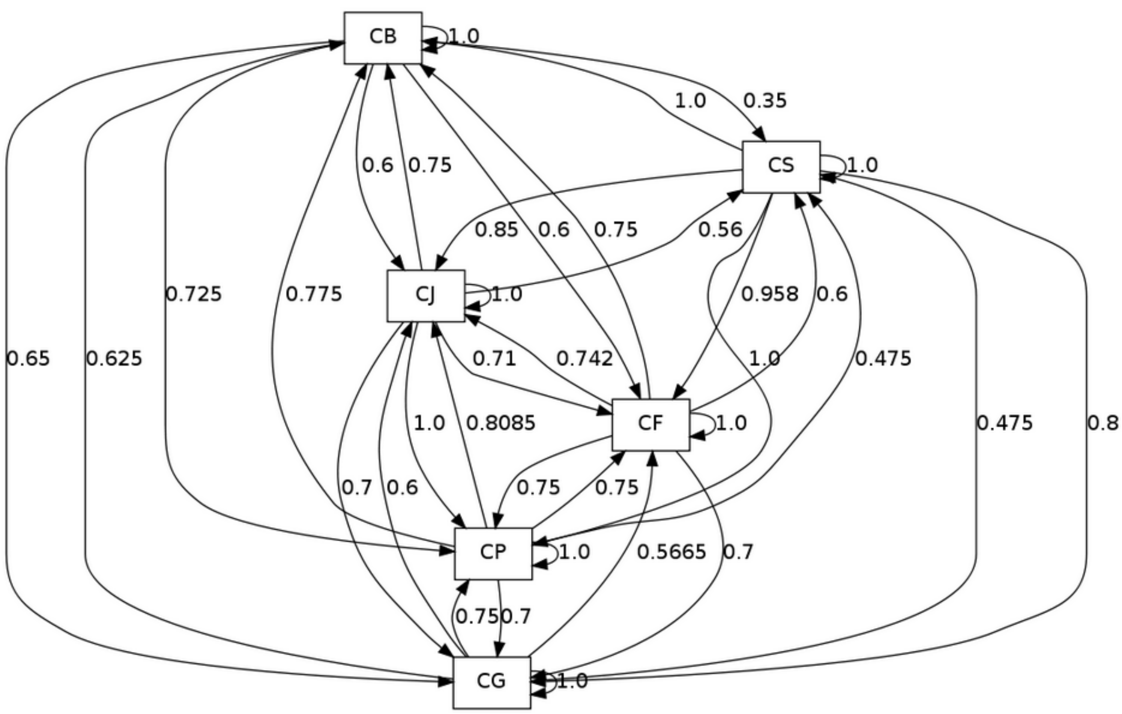

Figure 15: Credibility relations graph, leading results in 7.3.

Alternatives values

CB	4
CF	3
CG	4
CJ	2
CP	4
CS	1

Figure 16: Downwards distillation ranking, leading results in 7.3.

Alternatives values

CB	5
CF	4
CG	3
CJ	2
CP	6
CS	1

Figure 17: Upwards distillation ranking, leading results in 7.3.

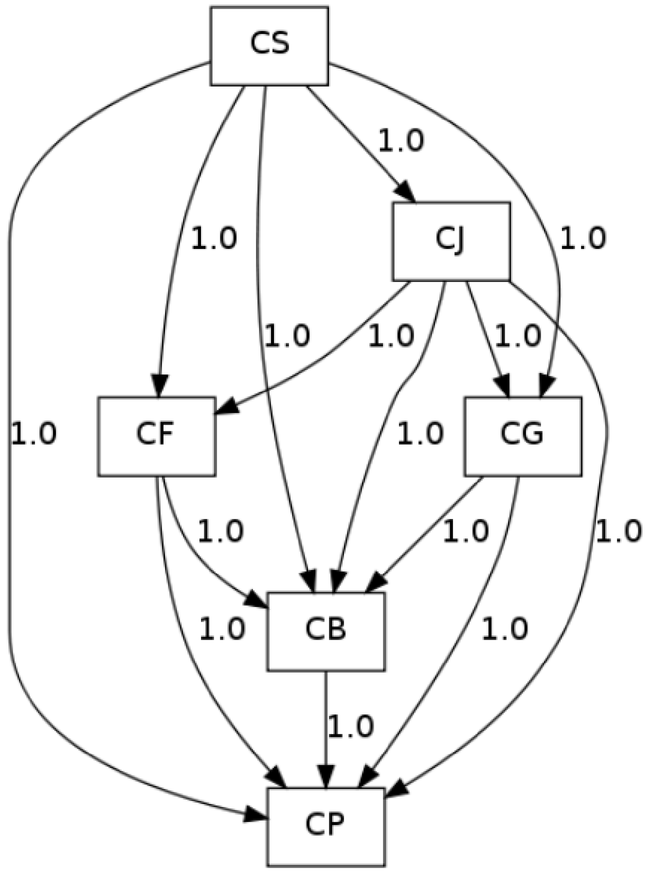

Figure 18: Intersection distillation graph, leading results in 7.3.

Alternatives values

CB	4
CF	3
CG	3
CJ	2
CP	5
CS	1

Figure 19: Final rank, which represents the same information than figure 4 in 7.3.

Appendix C. Diviz ELECTRE III design

The aim of this section is providing a brief view on the system built on *Diviz*(see diviz) software, for working with ELECTRE III method in this paper.

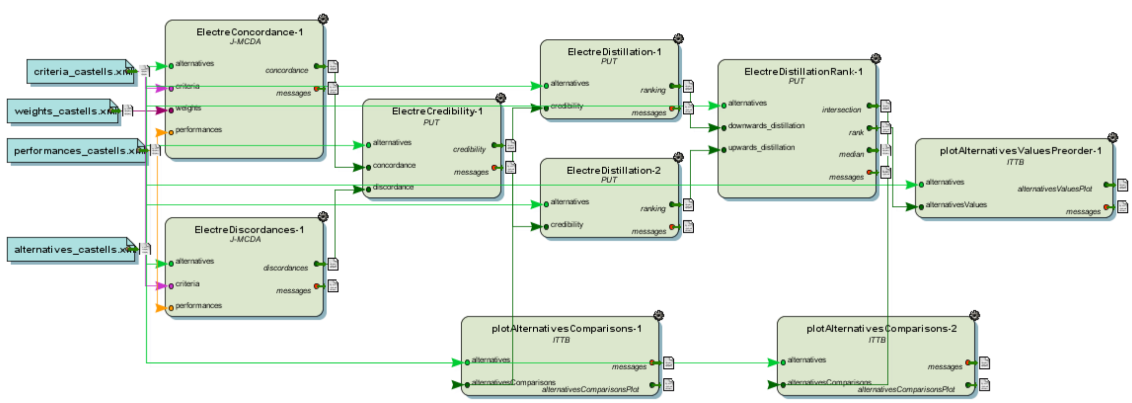

Figure 20: Diviz program screen shoot, showing the modules used for implementing ELECTRE III.

In figure 20 the *Diviz* modules used for performing the testing experiments, presented in 6, in this paper.